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CONTINUE THE FEDERAL HIGHWAY PROGRAM

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REPRESENTATIVE Wilbur Cartwright, of Oklahoma, chairman of the House Committee on Roads, is sponsoring a bill in Congress that provides for an additional appropriation of 400 million dollars for highway construction in the fiscal year beginning July 1, 1934.

¶ This measure, if adopted, will have the effect of continuing the federal highway program authorized by the National Industrial Recovery Act.

¶ The Cartwright bill is of the utmost importance to the friends of road construction. Because so many states have diverted their gasoline tax and automobile license funds to other uses, many state highway departments will have little to work with if left to their own resources.

¶ Little can be done toward correcting the situation in the various states, because the legislatures of forty-four states do not convene until next January. Until present emergency laws are repealed, the diversion will continue.

¶ Representative Cartwright and other Congressional friends of highway construction need your support. Give them that support—expressed in letters and telegrams.

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Vol. XLII, No. 4 **Concrete** April, 1934

Rehabilitate Old Commercial Buildings with Reinforced Concrete

Consulting Engineer Urges Revival of Former Practice—How Wooden Floors Serve as Forms for New Concrete Slab—Nine Steps in Procedure

By DR. E. LEE HEIDENREICH
Consulting Engineer, Kansas City, Mo.

ONE form of private construction work which, in the author's opinion, offers a definite opportunity to firms of consulting engineers and architects, is the rehabilitation of old business and apartment buildings.

Fireproofing as Well as Rehabilitation

Most of the buildings of this type were built years ago, mainly of wood joisted interior construction, so that their structural rehabilitation involves also their fireproofing. This is true because the logical type of construction for the new interior is the slab type of reinforced concrete floor supported on reinforced concrete columns built within the old exterior walls. Interior columns of the same construction type are necessary, of course, where the building is too wide to extend the floor span from wall to wall.

Because of the fireproof type of construction employed in such rehabilitation, vast sums may be saved annually on fire insurance premiums, both on the building and on the contents.

Many Old Buildings in Every City

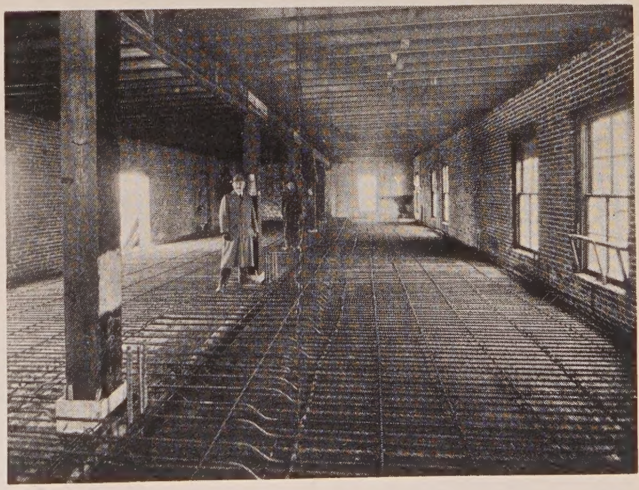
Buildings that offer exceptional opportunities for rehabilitation include the numerous old types of wholesale houses, warehouses, apartment houses, printing plants, storage plants, and so on, found in every city of consequence. Most of the buildings of this old type of construction are either three or four stories high, though in some cities they have been built as high as six stories. The apartment houses are mainly the three-story walk-up type; but some cities have in times past permitted the construction of buildings for this occupancy to heights greater than three stories.

Some years ago the author's engineering organization rehabilitated a number of old buildings in Kansas City, in the manner here described. Some of those buildings and the method of their rehabilitation were described in engineering magazines at the time. There is, in consequence, nothing new about the idea or the methods employed; and of even greater practical importance, there is no patent covering the method.

Owners Now Willing to Listen

There was a time, during the so-called period of prosperity of the last decade, when owners of such buildings and heads of firms occupying the buildings were not interested in the rehabilitation of old structures. If the owner of the building considered the question of construction at all, the only plan that entered his mind was that of tearing down the old structure and building a new one of larger size. He could easily borrow the money to do that. If the occupant became dissatisfied with the old structure, he moved into larger and more modern quarters.

Under present conditions, however, both owners and occupants will listen to proposals to extend or improve their old buildings by means of a reconstructed interior, and the construction of additional stories if more room is needed. The addition of more stories is a simple matter, since all the new construction is supported on the new reinforced concrete columns, which in turn are supported on independent footings. The old exterior walls are, as a matter of fact, relieved of the floor loads they formerly carried.



Inspecting reinforcement before placing concrete. Old wooden floor serves as form work for new concrete slab

Method of Procedure

To illustrate the procedure to be followed in work of this type, the following numbered paragraphs explain the various steps in the rehabilitation and fireproofing, some 15 years ago, of the three-story warehouse occupied by the Manhattan Phillips Refinery Co., of Kansas City. Reconstruction specifications called for three new floors, each to support a live load of 300 lb. per sq. ft., and a roof to carry a live load of 50 lb. per sq. ft. The method of procedure, which follows, was quite simple:

(1) The foundations were underpinned with three steel rails, forming reinforcement for an additional 3 by 6-ft. foundation slab on the side of the old foundations. Column steel reinforcement was put in adjacent to the old columns from the basement to the roof.

(2) The old building had 2 by 14-in. wood joists spaced 14 in. on centers. Every third joist was taken out, and a groove or slot, 6 in. high and 6 in. deep, was dug just above the old floor along the interior face of the brick walls of the building, to receive the new concrete floor slab.

(3) One girder was then jacked up at a time, to relieve the load on the corresponding wooden post. The post was then sawed off 5 in. from the floor, and a 2 by 12-in. wood block was slipped under it and tightened up with a wedge.

(4) A cleat was spiked on the post 14 in. below the girder, and a double 2 by 14-in. joist was spiked across the post under the girder to support two 2 by 14-in. joists placed under the old floor joists from post to post, and set 12 in. away from the old wooden girder.

(5) The old floor joists were then sawed off along these two supporting joists, after removing the old floor sheathings within the width of the new concrete girder.

(6) The underside of the form for the concrete girder was then placed and secured at the proper level, a 7/8-in. board was tacked to the sawed-off posts, and the girder steel was placed.

(7) A similar procedure was followed along both walls, after which the forms for the new concrete pilasters were built of some of the 2 by 14-in. joists removed from the old floor. Only every second joist was required for support of the fresh concrete to be placed.

(8) The steel reinforcement was then placed on top of the old wooden floor, as shown in the illustration, after which the concrete for the interior columns, the wall pilasters, the girders and the floor slab was deposited. Thus, in effect, the old wooden floor served as the form work for the new concrete floor.

(9) When the concrete had hardened, the wedges under the old posts were struck and the old floor was lowered, joists and all.

The Finished Product

The finished product thus appeared—a fireproofed reinforced concrete warehouse. Not a single board-foot of lumber had been bought for form work, for as previously stated, the old floor served as form work for the new.

This building was rehabilitated one floor at a time, the work having proceeded, naturally, from bottom to top. The wooden stairs were replaced with stairs of reinforced concrete construction.

Once again, the author urges firms of consulting engineers and architects to study the possibilities in this form of rehabilitation in their own cities, with the view of developing some remunerative business.

How Fort Atkinson Pushes Public Works Program

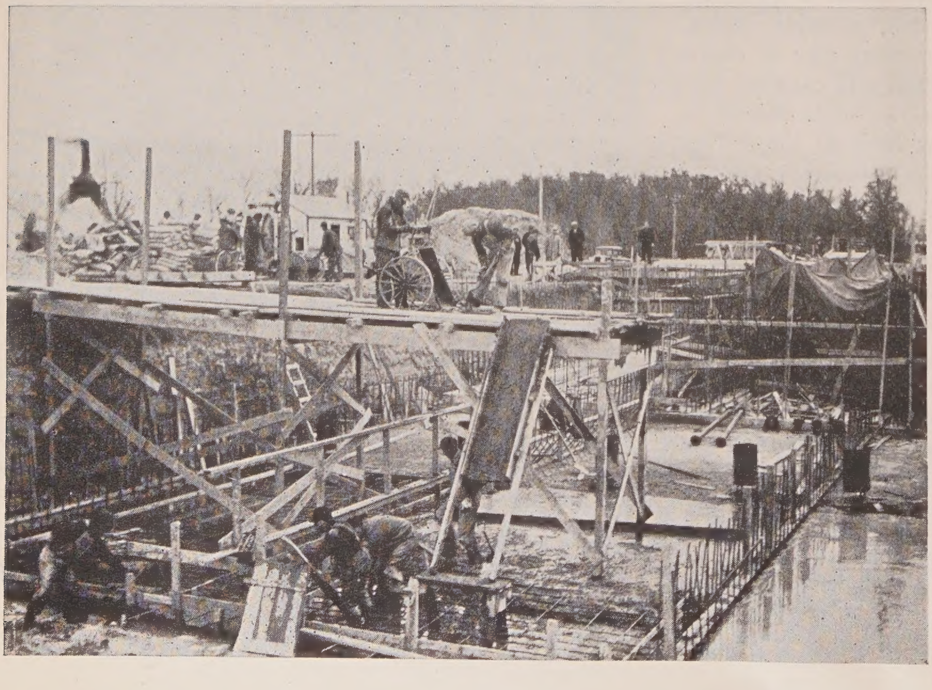
FORT ATKINSON, Wisconsin, is setting a noteworthy example to other small cities because of the energy and enterprise displayed in pushing its public works program.

While the PWA has authorized 30 per cent grants on several of the projects in this program, the city went ahead on its own power without waiting for the grants to be approved.

A sewer system, a sewage treatment plant, a water supply reservoir, a series of river walls, and other needed improvements, are included in the plant inaugurated last June. The sewer system and the sewage treatment plant have been completed. Other projects are still under construction.

Aside from the PWA grants of 30 per cent, this construction program has been financed through an issue of 8-year serial bonds bearing 4 per cent interest, and sold on a yield basis of 4.048 per cent.

A. J. Koenig, city manager, is given much of the credit for his constructive program of public works improvement.



Fort Atkinson's sewage treatment plant under construction

Selecting and Driving Concrete Piles

Soil Borings Essential—Load Tests Supply Most Reliable Information on Bearing Power—Selection of Driving Equipment

By L. R. NEED
Engineer, Westinghouse Electric and Manufacturing Co., Cleveland Ohio

FROM their introduction to the construction industry some thirty years ago, concrete piles have steadily grown in favor until today they are very commonly used. Their application presents peculiar problems, each construction job usually being considered from the viewpoint that the size and type of pile is indeterminate until test piles are driven or test borings made.

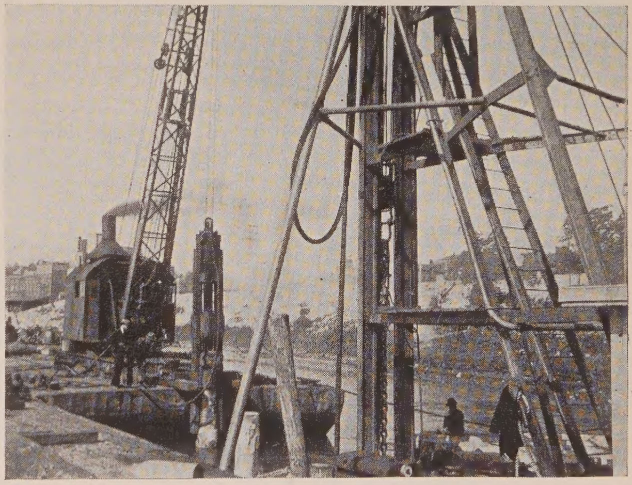
Must Learn Character of Soil

One of the first problems is to determine the character of the soil into which piles are to be driven. Test borings usually indicate whether piles should be of the friction or point-bearing type. As implied, friction piles are those in which sufficient friction is developed between the soil and surface of the pile to resist further penetration under blows of the hammer. Tapered piles are usually referred to as friction piles. Point-bearing piles, while developing a certain amount of friction, are dependent for good bearing power on their being driven to a hard stratum of gravel or rock so that the stresses from superimposed loads will be transmitted to the point, which will take a large percentage of the load.

If test borings are not practical, a cut-and-try method is usually followed, involving the driving of test piles preliminary to the manufacture or ordering of necessary piles for the job. Even with the information obtained from boring charts, it is common practice to drive test piles of both the tapered and straight type unless it is definitely known that one or the other is required. Test piles are usually chosen much longer than it is considered will be required.

Sixty-ton load test on concrete pipe

It might be of interest to mention the results of some pile tests conducted on a site where borings had been taken. Test piles of both friction and point-bearing type were driven and pulled. The borings showed approximately 8 ft. of black mud, fairly compacted by the overburden and quite free from water. Below this was a layer of sand and gravel, followed by clay. The clay stratum was sufficiently good to develop the 40-ton loading requirement, but was succeeded by a stratum of watery silt, having little resistance, and then by sand and gravel overlying rock. In order to obtain safe piles, it was necessary to drive through the silty layer into the sand and gravel just above the rock. Obviously, considerable pressure was exerted on the point of the pile and as a result the points of the friction or tapered piles were severely damaged. The point-bearing piles were naturally adopted for the job.



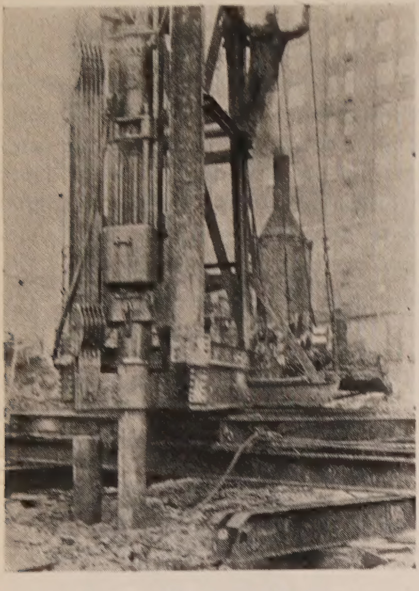
Two types of pile driving equipment—fixed leads on right, hanging leads on left

Considering the load requirements, concrete piles are usually loaded to 30 tons per pile and often to 40 tons. Many authorities state that the only accurate method of determining bearing power of a driven pile is actually to load the pile with weights and measure the settlement. When such load tests are conducted, it is common practice to make the test load equal to twice the required load, measuring settlement both before and after the lapse of so many hours under full load—usually 24 hours. A maximum settlement of ¼ to ⅜ in. is permissible.

Weight and Velocity of Hammer

As to equipment for driving piles, it is very important that the weight and velocity of the hammer are correct. Too little consideration is usually given to the size of hammer used. On some pile tests witnessed by the author the same hammer was used on a tapered (friction) pile and on a straight (point-bearing) pile which was more than twice as heavy as the tapered pile. Naturally the results were not comparable. The test borings in this case revealed soil conditions favorable to the use of friction piles. The friction pile was proved by tests to be the more practical from an economical standpoint.

Manufacturers of pile-driving machinery will recommend proper size hammers if given certain important governing conditions such as nature of soil, kind and size of pile, weight of pile, area of cross section of pile, and penetration required.



Typical equipment employing fixed leads, for driving concrete pipe

Efficiency in Pile Driving

Successful and efficient driving depends on the care taken to keep the hammer and the pile in as near perfect alignment as possible. For this reason pile hammers are arranged to slide in guides or leads which are usually part of the pile driving equipment. These leads are of great assistance in holding a pile preparatory to the first few blows of the hammer. After starting, if used properly, they keep the pile and hammer in line. There are two types in common use, namely, fixed leads and swinging leads. Swinging leads swing from the end of the boom on a movable crane. They are more difficult to handle, but are commonly used, probably due to the ability to change the entire equipment quickly from one pile position to another.

To offset the condition where the hammer is not kept dead true with the pile, suitable pile caps are generally furnished with hammers for driving concrete piles. These caps are arranged to house wood blocks or other suitable cushioning material, such as rope pads and old belting, which distribute pressure over the complete area of the head. An instance of inadequate protection may here be cited. Two test piles were driven on a bridge foundation job. The contractor had a double acting steam hammer for the job, but did not have a pile cap. It was decided to use several thicknesses of leather belting on the first pile. This proved entirely inadequate and the head of the pile was so severely damaged after the first few blows that driving was stopped. On the second pile 12-in. wood blocks cut from a wood pile were used as a cushion. Several different blocks were used before full penetration was reached, but at the required resistance to penetration (4 blows per inch) the head was in very good condition. Examination after pulling revealed no damage to the point.

Much more might be written on the selection and driving of concrete piles. The subject covers a broad field and no doubt every application would present something new and interesting. However, only a few of the more important and practical points have been presented in this article. Perhaps enough has been presented to give the reader a glimpse of the problems involved and the method of attacking these problems.

Resumption of the business rise, strengthening the banking structure, and improvement in public buying power will pave the way for revival in building, according to *The Brookmire* building and construction review and forecast.

Concrete Products Utilized in Rural Sanitation

CONCRETE products manufacturers may be overlooking a profitable market through failure to develop a greater demand in the field of rural sanitation. While some manufacturers cultivate this market, it is believed to have possibilities far greater than most products men realize.

The illustration shows the special precast concrete units just delivered to a Kansas farm, for concrete slab and riser-pit toilets. If this is multiplied by the number of farms in the community served by a products plant, the potential market becomes apparent.

Rapid Determination of Moisture in Fine Aggregate

Operation Requires Less Than One Minute If Proper Equipment Is Used in Combination with Chart—Method of Procedure

By WILLIAM MAYO VENABLE
Consulting Engineer, Blaw-Knox Company, Pittsburgh, Penna.

IN the manufacture of concrete it has become customary to specify the ratio of water to cement in the concrete to be used, as well as to specify the quantities and the physical characteristics of the other ingredients. The amounts of water in the sand and stone vary from day to day, and frequently from hour to hour. It is necessary, on the job, to make allowance for the water in the sand and stone in order that the amount of additional water used may be so regulated as to bring the total desired quantity to the right amount.

This regulation of the amount of water added requires either occasional or frequent determinations of the amount of water in the sand and stone as it is received. The amount of water in the stone does not vary as widely as the amount of water in the sand. The testing of the sand for water content is therefore necessary at more frequent intervals than the testing of the stone, and sometimes this presents a problem of considerable importance.

Specific Gravity Must Be Determined

Determination of the amount of water in a given sample of sand requires the application of nothing but old and well-understood principles. It is first necessary to determine the correct specific gravity of the sand in what may be called a normally dry condition—that is to say, with no surface water on the grains, but not roasted to such an extent as to dry out the water that is normally contained in the interior of the grains themselves.

The specific gravity of the sand being known, it is easy to weigh a sample of wet sand in the air, and then to weigh it submerged, and from the difference between these weights to determine the percentage of water by weight in the sample. No new principles are involved in doing this; but the procedure as outlined is rather slow and consumes a great deal of time.

Equipment and Samples

One of the most convenient ways of reducing this work and making it possible to determine moisture content in a comparatively short time is here outlined. Its rapidity depends upon using a container of invariable size and weight which can be completely filled with water, so that the total volume of water and other material in the container is always the same. The weight of the container is measured so that it is always possible to weigh the container with a given sample of material in it and then to weigh the same container with the same sample of material but having the container filled with water. These two measurements afford all the necessary information, if the specific gravity is known, for calculating the percentage of water. The process is still further simplified if the weight of the original sample of material in its natural condition is taken the same in every instance. When these conditions are met, it is possible to prepare a chart, by reference to which the percentage of moisture can be obtained at a glance as soon as the total weight of the container containing the given sample has been ascertained. Such a chart is here illustrated.

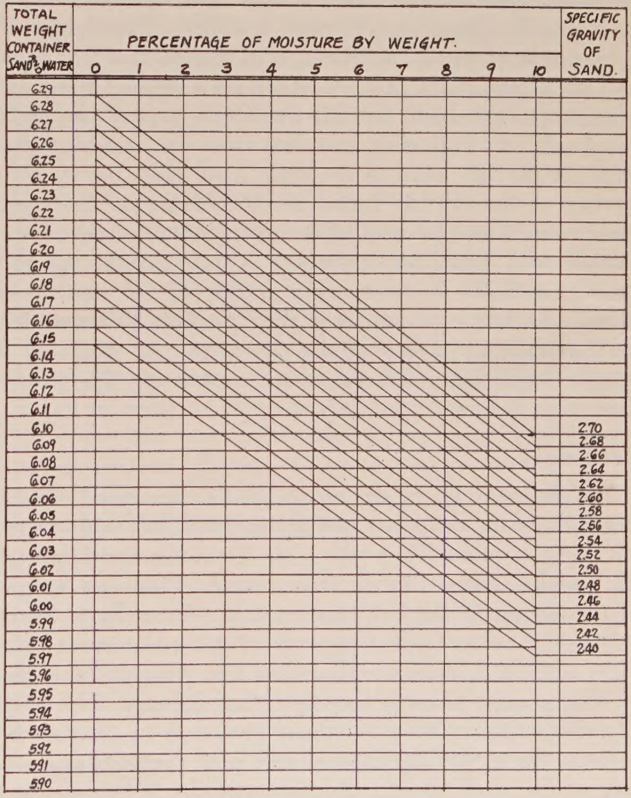


Chart for determination of percentage of moisture in sand

Preparation of Chart

It has been prepared for use with a container consisting of an aluminum pot with a close fitting cover of such shape that when the pot is filled with water and the cover placed on top and properly seated, the interior is entirely filled with water from the cover down, and any surplus water that overflows may be wiped off. The first step is to fill the container with water, place the lid on it, wipe off the surplus water and weigh the total. The chart here reproduced was made with a container which, when filled with water in this way, weighed exactly 4.4 lb. The exact volumetric content is not important, but should be sufficient to enable the container to hold the size of sample of sand to be tested and, in the present instance, the container was of such size as to contain 3 lb. of sand and allow considerable excess space for water.

After the weight of the container full of water has been determined, the next step is to dry out a sample of sand to the standard condition for determining its specific gravity and weigh out an exact amount of sand. The chart reproduced has been prepared by using a sample of sand weighing exactly 3 lb. This 3 lb. of sand is then placed in the container and the container completely filled with water, care being taken to see that the sand is thoroughly moistened by stirring; or the container may be filled with water and the 3 lb. of sand sifted into the water, thus insuring that it is thoroughly wet and stirred enough to make sure that no air bubbles are adhering to the grains. The lid of the receptacle is then placed upon it, the surplus water is wiped off, and the container, with the sand and water in it, is weighed.

Example Illustrating Use of Chart

With sands of the specific gravity ordinarily used, the weight of the sand, water and container under these conditions will be somewhere between 6.15 and 6.29 lb. It is most convenient to obtain the weight in pounds and hundredths of pounds, and this is readily done by using a scale in which the beam is calibrated suitably. The weight of the sample of sand and water is found in the left hand column of the chart. The chart shows a sloping line running downward from the left hand side toward the right hand side. By following this line from the weight of the sand on the left hand to the right hand side, the specific gravity of the sand is found in the column on the right hand side. Thus, by way of example, if the weight of the sample with water and container is 6.20 lb., the specific gravity is 2.50. If the specific gravity of the sand used is substantially constant, it is then possible to determine very quickly by means of the chart, and by weighing a sample twice, just what the water content is. The procedure is as follows:

Procedure

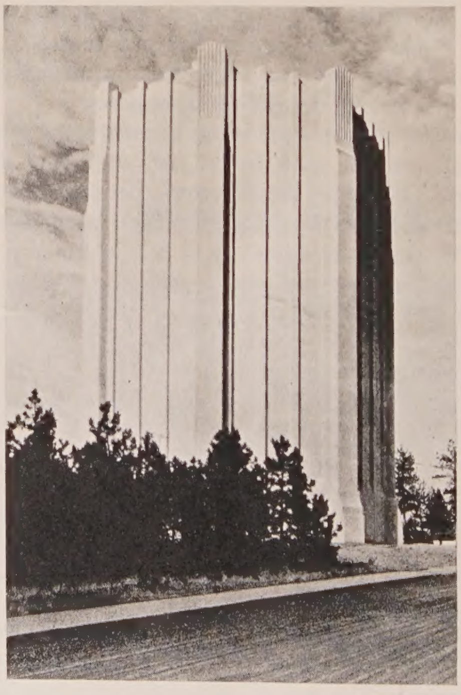
Weigh out 3 lb. of the moist sand to be tested. Place this 3 lb. in the container and fill the container with water, stirring the sand. Then place on the cover and wipe off the surplus water. Weigh this sample. Find this weight of the sample in the left hand column of the chart. From this left hand column follow the horizontal line to the right until it intersects a diagonal line running from the specific gravity given in the right hand column. The point of intersection of these two lines projected upward to the scale at the top of the column will give the moisture content of the sand sample. For instance, let it be supposed that the specific gravity of the sand is 2.50 and that the weight of the sample with the water is 6.13. The quantity of water in the sand will therefore be about 4 per cent by weight, and the amount of water to be added can readily be corrected to allow for this percentage contained in the sand.

The total time consumed in making this determination is that taken to weigh out 3 lb. of the material to be tested in its natural condition, to place this in the container, fill the container with water, and again weigh the sample, and after this refer to the chart. It is quite possible for a skillful person to conduct this operation in less than one minute, if necessary, and still have sufficient accuracy in the determination for practical purposes, if he is provided with a suitable balance and container for conducting the work promptly, and prepares a chart suitable for the quantities of material he is to handle and the weight of the container he is to use. The actual chart reproduced herewith could be used only if the container when filled with water weighs exactly 4.4 lb. There is practically no difficulty in obtaining a container with a lid on it which weighs a trifle less than this and adding to it enough weight to bring the total up to 4.4 lb., in which case the chart herewith reproduced can be used without alteration.

Practically all manufacturers of small scales are prepared to supply comparatively simple and cheap scales suitable for weighing quantities such as this with the beam calibrated in hundredths of pounds. The method, therefore, is readily available to anybody without having to purchase equipment from any particular manufacturer. If it were desired to work with a larger sample than 3 lb., a larger container should be used and a similar chart prepared.

Architectural Treatment of Concrete Shown in Water Towers

IN the December (1933) issue of CONCRETE, on page 4, there is an illustration and short description of a reinforced concrete water tower in Minneapolis that is remarkably attractive from the architectural point of view.



The Minneapolis tower is not without rivals for distinction in this respect. The illustration here shown is a view of a monolithic reinforced concrete water tower comprising a part of the water supply system of Spokane, Washington.

Seattle and Milwaukee are among other cities that have built reinforced concrete water towers having exceptional architectural merit. Designers should profit from these excellent examples.

Monolithic Concrete Expresses New Conception *of* Dwelling House Architecture

Architect Again Becomes Essential—How Beauty and Low Cost Are Attained — Homes May Be Fireproof, Stormproof and Shockproof

By BERNARD R. KLEKAMP
Klekamp & Whitmore, Architects, Chicago, Illinois

THE Century of Progress Exposition, held in Chicago in 1933 and to be repeated this year, has revolutionized the public's conception of dwelling-house architecture. From the opening day to the closing day of the 1933 exposition, continuous streams of humanity poured through the eight or ten modernistic dwellings erected by enterprising groups representing building material interests. More streams of humanity will pour through those buildings in 1934.

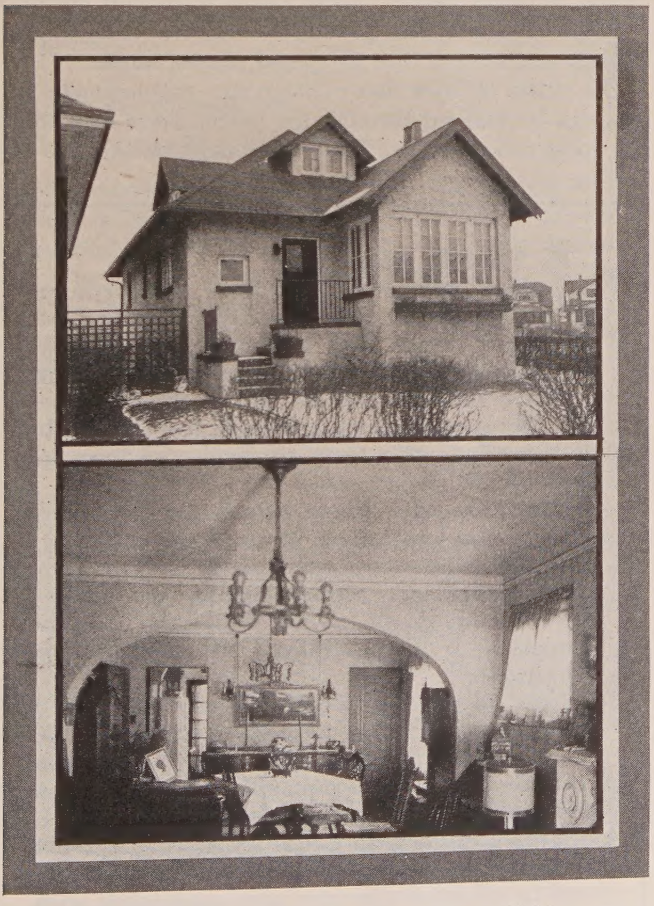


Figure 2. Exterior and interior of monolithic concrete home, having insulated exterior walls, and all interior finish applied directly to concrete

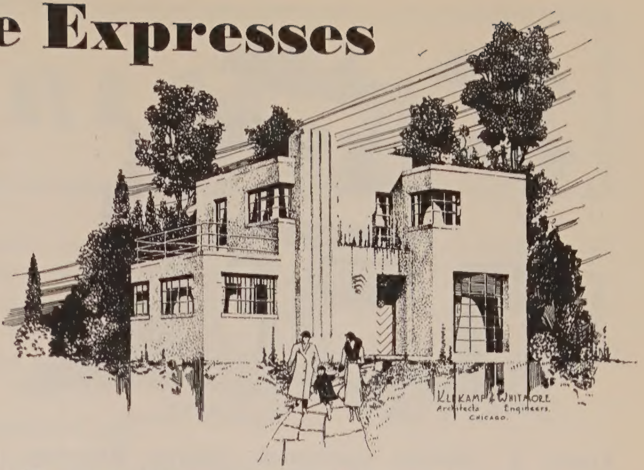


Figure 1. Five-room monolithic reinforced concrete house, designed in accordance with the Wedberg system, estimated to cost $3,720 in Chicago

Public Accepts Modernistic Dwellings

The public—or that part of the public that attended the exposition—looked at those buildings from the inside and from the outside. Millions who were not at the Fair saw pictures of those houses. Most visitors, perhaps, were surprised at the exterior beauty obtained with broad, flat surfaces and flat roofs. Architects know, of course, that this beauty was attained by proper proportioning of the masses, by the breaking up of roof lines, proper utilization of openings, and so on. That exterior beauty did not just "happen." It was attained only as the result of architectural skill.

Fireproof, Stormproof and Shockproof

In other directions, the more intelligent classes of people have revised their ideas about residential construction. I refer to the growing appreciation of the fact that the single-family dwelling, no less than the large apartment-hotel, may be built fireproof, stormproof, and proof against damage from earthquake shock. Intelligent people are not so easily deceived as they were ten years ago. Now they know that there is no need for the wholesale damage and destruction of small homes such as occurred in the southern California earthquake of a year ago, or in the Berkeley (Calif.) fire, or in the numerous hurricanes and tornadoes which the country has experienced.

For the spreading of this greater wisdom among the enlightened masses, much credit is due the Portland Cement Association and the magazine CONCRETE. And, logically enough, the material concrete is probably the most effective with respect to resistance against fire, storm and earthquake, and also with respect to economy. Above all, it is an excellent medium for architectural expression.

The Architect Becomes Essential

Here, then, is where the architect enters the scene. If single family dwellings of the modernistic type of architecture—which we may term the Century of Progress style—are to be things of beauty, they must be designed by skilled architects who have a full knowledge of the material with which they are working.

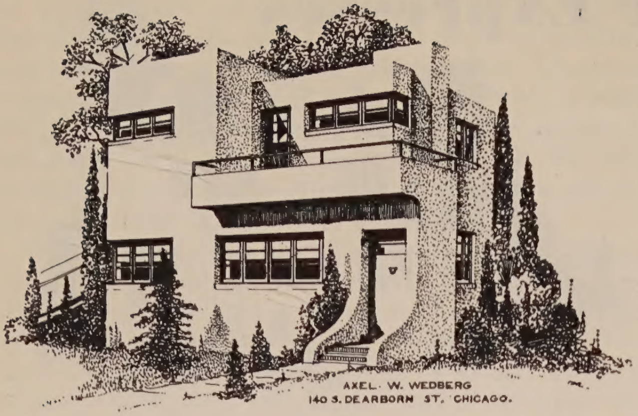


Figure 3. Another modernistic concrete five-room house, estimated to cost $3,400, based on Chicago prices

An architect who enters this field must not allow himself to be guided by the set rules of a past age. He must create his own individual orders of design. He must recognize that the trend of the whole world is toward color and toward beauty in simplicity. He must combine the practical layout of rooms and the arrangement of windows so as to produce offsets in the exterior outline, which, together with color, gives charm and character to the building. He must have the courage to avoid needless cost, as, for instance, by eliminating all interior plaster work; and out of similar considerations of economy he must think in new terms in matters such as the construction of walls, floors, and partitions.

When the architect applies these new thoughts and principles to the design and production of modern low-cost homes, he will have made his services far more essential than is the case at present, and he will bring the modern single-family home within the financial reach of a great mass of wage and salary earners.

Getting the Full Value of Concrete

Monolithic reinforced concrete construction for homes will meet all the requirements previously outlined—beauty with simplicity; safety against fire, storm and earthquake; insulating value and low cost. These qualities have been realized in a new method of monolithic concrete construction developed by Axel W. Wedberg, a Swedish engineer. Houses were built in accordance with this method, some six or eight years ago, in New York and Chicago. The halftone illustration (Figure 2) shows views of a home built in Chicago in 1927, at 5201 Liano Ave.

The outside walls of this home are of reinforced concrete, but two layers of continuous insulation, with a dead air space between them, were embedded in the concrete. In principle, the construction of these walls is similar to the wall of a thermos bottle. The partitions and floors, likewise, are of monolithic reinforced concrete, deposited one story at a time, including walls, partitions and floor.

All Plaster Work Eliminated

The interior, as previously explained, is finished directly on the concrete, all plaster work having been eliminated. The very attractive interior finish was obtained with a heavy paint that produced a texture finish. These views were taken in February of this year, and they show the excellent condition of both the exterior and the interior of this 7-year-old house. In a recent interview the present occupant of the house, who has lived in it for four years, had nothing but praise for all features of the building. He mentioned in particular the ease with which it is kept warm during sub-zero weather.

Figure 1 shows a monolithic concrete house designed by the writer, in which this same system of construction is to be employed, but in which a modernistic appearance has been created by simple offsets in the exterior walls. A careful estimate of the cost of this 5-room house, based on present Chicago prices, totals $3,720, including a full basement divided into rooms, insulated exterior walls, hardwood floor "tile" throughout, steam heat, complete steel kitchen cabinets, a fireplace, and complete interior decoration applied directly to the concrete. The building shown in Figure 3, slightly smaller than the other, is estimated to cost $3,400 on the basis of present Chicago prices.

Why Low Cost Is Attained

Architects who may question these figures are reminded of the manner in which dwelling houses are usually built, how enormous amounts of labor and material are expended in the costly work of covering one material with another, covering joints, stopping air leaks, and in interior plaster work. In the type of construction here described, this needless waste is avoided.

The walls and partitions of these concrete buildings are formed in specially designed metal molds, developed by Mr. Wedberg. These molds consist of large panels made of a single sheet of metal, the edges of the panels being accurately formed with dies and shaped to fit perfectly against adjacent panels. Their length is the full height of a story. These molds produce a surface that is more straight and smooth than the usual plaster finish.

The writer believes that even greater proportionate savings can be realized through the use of these methods in the construction of fireproof apartment buildings.

No Time to Read?

Says a returned contractor subscriber: "I have missed your monthly edition of 'Concrete' since we cancelled it. Kindly send me a copy of your February issue and put my name back on your subscription list. My experience has taught me the truth of the adage 'No time to read, no time to succeed.' "

The man who wrote this letter is a contractor who specializes in concrete construction. He is in every sense of the term a concrete contractor. Some months ago he decided to cut down on his expenses, and he cancelled a long-standing subscription to "Concrete."

Now he has learned that some things are indispensable to a concrete contractor, if he is to keep abreast of new developments. One of those indispensable things is the publication that covers his particular field.

This applies with equal truth to engineers and architects, to products manufacturers, and to all others in any way associated with the use of cement and concrete.

◆ EDITORIAL ◆

Construction Comes Up with a Bang

AFTER suffering a decline in January and February, due in considerable part to unusually severe weather conditions, construction contracts have come back with a bang.

Although weather conditions in March have been anything but lamb-like throughout the greater part of the month, contracts awarded in the 37 states east of the Rocky Mountains during the first fifteen days of March were practically equal to the awards for the entire month of February.

This upward leap in construction contracts comes at a most opportune time, along with other favorable news such as the steady increase in industrial production, employment and payrolls; the continued increase in freight car loadings and net railway earnings; strength in steel production and in department store sales; and—most important of all—the settlement of the automobile labor situation.

With the skies clearing, both literally and figuratively, the way is open for the improvement in the construction industry which has been so generally predicted, and which seems at last to be in actual development.

Century of Progress Again Promotes Housing

THE colony of modern homes at the new World's Fair of 1934 will be bristling with new ideas and suggestions. Every house is to be completely redecorated. Some will be extensively remodelled. Others are to be removed, and in their place newer efforts and experiments will appear. The landscaping has the aid of a season's start. Gardens, massed shrubbery, wide lawns and flowers will furnish an improved setting for these homes.

Two new structures in the 1934 modern homes group will be a 2-story steel house and a 5-room bungalow of the same material. There will also be a display of a group of full-size model sections demonstrating the chief essentials of steel house construction and showing the progress that has been made in such utilization of that metal.

Two other houses, which, while not physically a part of this group, are so related to it as to make their inclusion essential, are the farm houses being built as a part of the farm show.

One home is to be a model farm house of 1950, with working quarters on the first floor and living quarters on the second. The first floor will include the kitchen and a shower room, milk room, tool and storage room. The house will be planned with the maximum functional utility and efficiency in mind.

The second house, called the subsistence farm house, is to be a structure of four or five rooms built not to exceed a cost of $3,000. This house is being designed to meet the needs of the present-day effort to get people on farm plots in which all or a great part of the family living can come from the soil.

Control of Highway Loadings

THE American Association of State Highway Officials, as the result of several years of research into the subject of vehicular traffic and highway design, has inaugurated a movement toward uniformity in state regulations covering allowable highway transport loads.

The recommendations of the A. A. of S. H. O. are published in a 16-page pamphlet under the heading "Who Shall Use the Highways, and How?"

State legislatures are urged to adopt these uniform standards as a means of reducing transportation costs, protecting the public and the highways, promoting efficiency in the interstate operation of motor transport vehicles, and removing from our highways undesirable equipment and operating practices.

No less than forty-four state legislatures will be in session in the early months of 1935. It is not too early for state highway departments to join in this campaign for uniformity, and to start laying plans for introducing and pushing the necessary regulatory measures in their respective state legislatures.

Copies of the pamphlet should be placed into the hands of every state legislator.

Concrete to Create Water Areas

THE U. S. Department of Agriculture announces the appointment by Secretary Wallace of a committee to outline a course of action under a proposed plan to utilize unproductive farm lands for the creation of water areas to provide nesting and feeding places for migratory and upland game birds. Provision will also be made for fish culture.

Undoubtedly the development of such water areas will require a considerable amount of concrete construction in dams, bulkheads, and various miscellaneous items. Tentative plans call for the ultimate withdrawal of some fifty million acres of land for this purpose.

Considering a single project this may be regarded as a minor use of concrete; but the vastness of the program means that the aggregate amount of concrete required will be large. From the standpoint of self-interest as well as the general well-being, the concrete construction industry will find it worth while to support this plan, and to disseminate information concerning it.

PROGRESS — In a Page

Current activities in research, in matters pertaining to concrete and cement, as being carried on or completed by various organized groups.

Cement Investigations in 1933

COMMITTEE C-1 on Cement, of the American Society for Testing Materials, has made a new series of plastic mortar compression tests, making use of 12 cements.

A report, including tests up to 6 months, was also compiled on the effect of varying SO_3 content on cements for low, medium and high tricalcium aluminate.

A study of methods of chemical analysis was undertaken and ten laboratories are now co-operating in a comparative study of certain methods. The subject of sub-sieve particle size continued to be of much interest, and a second series of co-operative sub-sieve fineness tests is being carried out. Work is also progressing in the studies of volume change and soundness of portland cement, time of setting, blended cements, plasticity, low-heat cements, and high-early-strength cements.

P. H. Bates, in a paper on "Status of Specifications for Hydraulic Cements in the United States," discussed conditions under which cements are used. He questioned the possibility of any single type of cement being able to meet satisfactorily the numerous service conditions in such structures as a dam, a reinforced-concrete building and a road. He proposed separate cements for particular applications which should exhibit, respectively, qualities of high-early strength, plasticity, low heat of hardening, low volume change and resistance, to moisture and aggressive solutions; also two cements similar to the standard portland, one being lower in lime and higher in silica than the other.

A number of important developments on various phases of the cement and concrete research studies being carried on in connection with the Boulder Dam project were reported in several papers. Studies by R. W. Carlson and G. E. Troxell on "The Effect of Adding Siliceous Material to Portland Cements Upon Volume Changes, Compressive Strength and Heat Generation," throw some light on the advantages derived from blending portland cement with a volcanic ash.

Mortars for Unit Masonry

COMMITTEE C-12 on Mortars for Unit Masonry, representing the American Society for Testing Materials, completed its organization early in 1933. Since a review and correlation of existing data on mortars is essential as a basis for outlining a comprehensive program of research, the officers are working on this project and are soliciting funds so that a critical digest can be prepared. Once the information is available, the committee can proceed with tests and investigations without duplicating previous work.

Subcommittee VIII on Mortar Aggregates, a subgroup of Committee C-12, is collecting samples of typical mortar sands which are used in this country. An outline of the study of character of sand upon its mortar-making properties is being prepared and a bibliography is in course of compilation.

The subcommittee on preparation of mortars has developed specifications and these are to be circulated among those interested, for criticism. The group working on unit masonry construction practice has studied factors which must be considered in building watertight masonry walls with special reference to design and workmanship, and is preparing a preliminary draft of recommended practices for the use of mortars.

The program of work of the subcommittee on permaability tests is to be based on the results of a preliminary survey which has been made of factors involved in the permeability of masonry construction with particular reference to mortars and masonry units. A comprehensive program has been prepared by the subgroup working on efflorescence and staining and substantial progress has been made in assembling information relating to this subject as affected by mortars.

More Highway Research Abstracts

HIGHWAY Research Abstracts No. 7, dated February, 1934, an 8-page multigraph, contains a number of abstracts of articles and reports dealing with matters of interest to highway engineers. The subjects covered include—

(1) Surface Scaling of Concrete Pavements on Illinois State Highways, from an unpublished report.

(2) Influence of Type of Cement Upon Corrosion, and Nature of the Attacking Solution, by Dr. Karl E. Dorsch (Germany).

(3) Road Tax Diversions (from annual report of secretary of American Association of State Highway Officials).

(4) High-Early-Strength Cements, from Technical News Bulletin No. 192, April, 1933, issued by U. S. Bureau of Standards.

(5) Clay Coatings on Gravel Aggregates, by W. D. Beers (Utah).

(6) Influence of Temperature on the Strength Development of Concrete, by N. Davey (England).

(7) Tests on a Reinforced Concrete Arch of the Arlington Memorial Bridge, by Cyrus C. Fishburn and John L. Nagle (U. S. Bureau of Standards).

Copies of the "Abstracts" may be obtained at 15 cents each, from the Highway Research Board, 2101 Constitution Ave., Washington, D. C.

A. S. T. M. Investigates Blended Cements

GROWING interest in blended cements—in which siliceous materials are ground with ordinary cement clinker —has resulted in the appointment of a subcommittee of Committee C-1 of the American Society for Testing Materials, to study blended cements.

The chairman of this new subcommittee is G. O. Gardner, superintendent of the Ash Grove Lime and Portland Cement Co., Chanute, Kansas. Other members of the subcommittee are R. E. Roscoe, chemical engineer, Bessemer Cement Corp., Youngstown, Ohio, and J. L. Miner, of the Atlas Lumnite Cement Co., New York.

Co-ordination of Basic Principles of Concrete Mixtures

Absolute Volume Combinations as Measure of Yield Are Subject of Final Article of Series—Accuracy Essential with Ready-Mixed Concrete

XV—Supplementary Principles and Co-ordination (Concluded)

By **JOSEPH A. KITTS**
Consulting Concrete Technologist, San Francisco, Calif.

THIS final chapter in this series of fifteen articles takes up the problem of predetermination of yield from concrete mixtures, a matter of exceptional importance in the operation of a ready-mixed concrete plant.

(6) LAW OF YIELD OF ABSOLUTE VOLUME COMBINATIONS

The most fundamental principle of concrete mixtures, shown by the "elementary volumetric composition" of mortars and concretes, was instituted for laboratory research, prior to 1892, by the distinguished French authority on concrete physics, René Feret, and was introduced by him in Annales des Ponts et Chaussées, II, 1892. This principle is expressed by Feret's equation

$$c + a + w + v = 1.0 \quad . \; . \; . \; . \; . \; . \; . \quad (10)$$

in which c, a, w and v are the absolute or "elementary" volumes of cement, aggregate, water, and entrapped air voids, respectively, in a unit volume of mortar or concrete.

Absolute Volume Long Disregarded

It does not appear that the elementary volume was used as the practical basis of proportions until adopted by the author, in January, 1925, on the Yosemite Valley railroad relocation for the Exchequer Dam project, California, some 33 years after its introduction for laboratory research by Feret. Accustomed to thinking in terms of the bulk volume measure idea, which had been handed down the ages, it was not readily seen how this simple, logical and fundamental idea of the elementary volume could be adapted to practical proportioning of concrete. In the first place, we were accustomed to thinking of the voids in the bulk volume of aggregate instead of the density of solids in the bulk volume; and our other standards of measure were unscientific, and are so to this day.

The American standard measure of the weight of aggregate is pounds per cubic foot of dry and compact (priorly loose-dry or loose-moist) volume, instead of pounds per cubic foot absolute volume. That of moisture in the aggregate is taken as pounds of water per pound of dry aggregate, instead of volume of water per unit absolute volume of aggregate. Absorption of the aggregate is taken as weight of absorbed water to weight of dry aggregate, instead of volume of water absorbed by a unit absolute volume of aggregate. Silt content is taken as both inundated sedimentary volume of silt to inundated volume of aggregate, and weight of dry silt to original weight of dry aggregate, disregarding the differences in bulking and specific gravity. The standard measure is of the voids in the aggregate, instead of the density of absolute volume (or solids) in the bulk volume. The amount of 94 pounds of standard portland cement is regarded as one cubic foot, instead of 0.485± cubic feet absolute volume.

Unscientific Proportioning Methods Continue

These prevailing unscientific physical measures are heritages from ancient times and it has been difficult to adapt Feret's scientific laboratory-technique measures to practical use in the field, especially, when approaching the subject from the English or American units of measure instead of the metric system.

It does not appear that Feret gave thought to the adaptation of his elementary volumes to use as the practical basis of proportions; and the fact remains that, today, with few exceptions, concrete physicists the world over are still thinking, and conducting concrete research, in terms of the ancient bulk volume as the basis of concrete proportions. This is evidence of the abstruseness of the problems of adapting Feret's logical elementary volumes to use as the practical basis of proportions. Looking at the accomplished fact, the absolute volume technique is very simple to the young student starting with no prior knowledge of concrete mixtures and of the established standards of measure of the physical characteristics of aggregates, cement and concrete. The student of today should appreciate, however, that we earlier students of concrete mixtures were first inoculated with the ancient ideas of proportions and physical measures and then inherited the task of trying to make scientific sense out of mixture research based on these unscientific and indefinite measures of proportions and physical characteristics.

Key to Absolute Volume Measurement

In 1907, after 12 years of practical knowledge of concrete making and of the arbitrary ratio and void theories of proportioning, the author became familiar with Feret's law of the elementary volumetric composition of mixtures and saw at that time the desirability of employing the absolute volume as the practical basis of proportions. The problem was studied with much application and persistence but with little progress, from 1907 to 1923. One important result in the interim, however, was the inception (at the Panama Canal, 1912) of the "weight-volumetric" technique of physical tests—the present development for aggregate tests being as given in Part II, CONCRETE, June, 1932, pages 14 to 16. Abrams' water-cement ratio strength law, criteria of cement content and of maximum permissible fineness modulus (Bul. I, 1918), and Talbot and Richart's co-ordination of absolute volume proportions, uniform grading, water-cement ratio and fineness modulus (Bul. 137, U. of Ill., 1923), were essential developments of principles of proportioning before a practical absolute volume technique could be applied with satisfactory results. Bulletin 137 supplied us the missing elements of scientific proportioning in 1923, and, with this very essential assistance, the author began to see, definitely, that the key to practical application of the absolute volume, as the basis of measure of proportions and for concrete physics in general, was the adoption of new standards of measure, of the physical characteristics of aggregates, cement and concrete, consistent with the absolute volume measure.

A clear understanding of the Feret law of the elementary volumetric composition of concrete mixtures; a proper appreciation of the importance of the elementary or absolute volume technique of proportioning, testing, and analysis; the expedient and efficient practical use of the absolute volume as the basis of proportions; and a thoroughly practical and scientific concrete technology—each depends upon logical understanding and use of the following consistent physical measures:

g, Apparent Specific Gravity of Porous Solids (Cement, Aggregate, or Admixture Particles):

Weight of dry solids in grams per cubic centimeter of elementary volume; or, weight of dry solids divided by weight of water displaced by the solids in an exactly absorbed condition. The "apparent" specific gravity is the specific gravity of the "apparent" (or "absolute," or "elementary") volume (variously named by different authors). This volume, in concrete physics, comprehends the volume within the surfaces of the particles, including the microvoids (porousness) within the particles. This measure is a universally accepted standard.

m, Moisture Content in Aggregate:

Volume of water per unit absolute volume of aggregate; or, g times weight of moisture divided by dry weight of aggregate.

a, Absorption of Aggregate:

Volume of water absorbed by a unit absolute volume of aggregate; or *g* times weight of water absorbed divided by the dry weight of aggregate.

m', Free Moisture in Aggregate:

Volume of free water per unit absolute volume of aggregate; equals $m - a$.

d, Density of Aggregate:

Absolute volume of aggregate per unit bulk volume in the natural loose moist condition as measured; equals weight of loose moist aggregate per cubic foot bulk volume divided by 62.4 $(g + m)$.

v, Voids in Aggregate:

Void space per unit bulk volume of aggregate in the natural loose moist condition as measured; equals $1.0 - d$.

b, Bulking of Aggregate:

Ratio of the loose moist bulk volume to the corresponding absolute volume; equals $1.0/d$.

w, Weight of Aggregate:

Weight of moist aggregate for unit absolute volume of aggregate; equals 62.4 $(g + m)$ for pounds per cubic foot absolute volume.

f, Fineness Modulus of Aggregate:

Sum of the absolute volume proportions retained on each of the U. S. standard sieves Nos. 100, 50, 30, 16, 8, 4, ⅜ in., ¾ in., 1½ in., etc.

C_v, Absolute Volume of Cement per Given Weight (Pounds):

Given weight of cement divided by 62.4 times its apparent specific gravity.

K_a, Density of Concrete:

Solids per unit apparent volume of fresh concrete; equals sum of the absolute volumes of cement, aggregate and solid admixture divided by the volume of concrete. (This would be more properly called "theoretical density," since the true density of the set concrete is affected by shrinkage in setting, chemical combination of water and cement and, sometimes, by combination of cement and admixture.)

K_y, Yield of Concrete:

Apparent volume of fresh concrete divided by the sum of the absolute volumes of its ingredients—aggregate, cement, water, and admixture—with allowance for absorption of the aggregate, or

$$K_y = K_v/(A_v + C_v + W_v + M_v) \quad \ldots\ldots\ldots \quad (36c)$$

in which A_v, C_v, W_v, and M_v are the absolute volumes of aggregate, cement, water, and admixture, respectively, W_v including the added water plus the free water in the aggregate but not including the allowance of absorbed water in the aggregate.

MIX CONSISTENCY AND AGGREGATE MODIFY FERET'S LAW

Feret's law of the elementary volumetric composition of mixtures was based principally on tests of comparatively dry or stiff sand-cement mortar mixtures. As a consequence, the yield, K_y, was indicated by his tests as unity or greater because (as we now know) his dry mixtures entrapped enough air to exceed the volume of cement going into solution with the mixing water.

The amount of concrete obtained ranges from 90 per cent of the sum of the absolute volumes of ingredients, for rich and wet mixtures, to 110 per cent, for lean and dry mixtures, considering practical limits of cement content and consistency, and from 96 per cent to 102 per cent for the more usual mixtures. The usual values signify the fundamental importance of the Feret law of the elementary volumetric composition of mixtures.

Need Greater Accuracy in Yield

The tentative (American) standard specification for the measurement of ready-mixed concrete volume assumes that K_y is always unity. This sometimes compels the contractor to buy 1,040 cu. yd. of concrete to do a 1,000-yd. job; and the honesty and competence of the producer is questioned, with sad consequences. It is essential that we determine reasonably accurate values of K_y for the various conditions.

Based on average values of 3/16-in. maximum size gravel aggregates in Tables 1, 6 and 7, pages 50, 64 and 69, respectively, of "Report of the Director of Research" published by the Portland Cement Association, November, 1928, the following equations of yield of absolute volumes are obtained for various slumps, in accordance with our Eq. 37:

Slump, in.	Equation of yield, K_y	Flow
1	$\log K_y = 0.100904 - 0.033850 \log C$	157
2	$= .092540 - .031467 \log C$	185
3	$= .082623 - .028676 \log C$	196
4	$= .077195 - .027253 \log C$	205
5	$= .069964 - .025305 \log C$	214
6	$= .065555 - .024367 \log C$	224
7	$= .064296 - .024538 \log C$	236
8	$= .065912 - .025799 \log C$	250
9	$= .076400 - .030239 \log C$	258
10	$= .105338 - .041258 \log C$	292

The theoretical values agree with the average measured values within one-half of one per cent for the practical range of cement contents.

It is seen that, for a given cement content, the yield decreases as the slump or water-cement ratio increases; and, for a given slump, the yield decreases as the cement content increases. As increase of maximum size decreases the amount of water required for a given slump, we can infer that, for a given cement content and slump, the yield increases with increase of maximum size and, likewise, with fineness modulus.

For ¾-in. to 1½-in. maximum sizes of gravel aggregates and mixtures of average cement content and consistency (2,000 to 3,000-lb. concrete of 6 to 8-in. slump), the yield is found to follow closely our equation—

$$\log K_y = 0.11752 - 0.04411 \log C \quad . \; . \; . \quad (37c)$$

in which C is pounds of cement per cubic yard of concrete.

This completes the six required laws of mixtures, specified in Part IV,[1] and provides means of proportioning concretes of any practicable combinations of maximum size of aggregate, strength and slump of concrete, employing any number of size separations of aggregates. Only the questions of choice of maximum size of aggregate and slump of concrete remain.

CHOICE OF MAXIMUM SIZE OF AGGREGATE; OPTIMUM SLUMP

The maximum size of aggregate should be as large as practicable to use. It should not be greater than ¾ the space through which it must pass, 1/3 the depth of slab, ¼ the width of wall, and as dictated by the conditions otherwise.

Stiff mixtures require less cement for a given strength than fluid ones, but require more labor or mechanical power in placing. For architectural and reinforced concrete it is generally essential that the mixtures be fluid, but not sloppy. The optimum slump, or the slump which gives the best combination of results in workability, flowability, and cohesion of the fresh mix, strength, density, and economy of the resulting concrete, and is satisfactory for reinforced, narrow and difficult sections, has been determined by the author for various maximum sizes of gravel aggregates, as follows:

Maximum Size, in.	¾	1¼	3	4½
Optimum Slump, in.	8	7.5	6	5

This relation of slump to maximum size of aggregate follows the equation—

$$\log s = 0.943914 - 0.054432\, D \quad . \; . \; . \; . \; . \quad (56)$$

in which s is the optimum slump, and D is the maximum (square hole) size of aggregate, both in inches.

Slumps in accordance with this criterion are proper for chutes on 40 per cent grade. They serve to minimize entrapped air bubbles. They are suitable for architectural surfaces, reinforced sections and structural fireproofing. Less slump may be used in favorable situations: heavy walls, ½ in. less; floorslabs, 1 in. less; large footings, 2 in. less; pavements, 3 in. less; and additional labor or power employed in tamping and vibrating will permit from ½ to 3 in. less slump than the foregoing. It is better practice to provide for ample slump and its greater requirement of cement than to provide for insufficient slump and its corresponding lesser and insufficient requirement of cement.

CONCLUSION

The practical application of the foregoing chapters is found in the November and December, 1931, issues of CONCRETE.

The empirical laws of effect of cement content, water-cement ratio, maximum size, fineness modulus and grading of aggregate, in relation to strength, density, consistency and yield of concrete, have been shown quite definitely and co-ordinated. This co-ordination, with the empirical criteria of law constants, provides an expedient calculation technique of formulating mixtures for concrete of any strength, slump and maximum size of aggregate. The empirical law constants for gravel aggregates and normal standard portland cement are based on the most comprehensive and reliable criteria and provide a proper basis for trial or research mixtures, under any particular conditions, and for determination of the corresponding new constants.

The final co-ordination comprehends the following basic principles:

1. The cement content and grading fundamentals of the arbitrary ratios, 1:2:4, etc.
2. The filler-to-voids principles.
3. The principle of synthesis or trial mixtures.
4. The density principle of Feret.
5. The uniform-grading-density principles of Fuller-Thompson, Graf, Hermann, Talbot-Richart, and others.
6. The water-cement ratio strength law, and fineness modulus principles of Abrams.
7. The author's laws of cement content, fineness modulus, yield of concrete, and optimum slump; and, most important:
8. The absolute volume basis of proportioning instituted by Feret—the foundation of the physics of concrete materials and mixtures.

This co-ordination of basic principles of mixtures provides a definite basis for mixture research under given conditions of materials, technological facilities, mixing time, and of fine, coarse, regular, irregular or gap gradings, etc. It provides a definite basis of fixing or cataloging any trial mixture, in its place in the category of mixtures possible under the given conditions, so that it can be exactly duplicated at any time despite changes in moisture content and grading of the particular aggregates.

Acknowledgments

Important labors in research tests, in graphical and mathematical analyses, and in practical application, have been contributed to this development, since 1924, by Richard Barry, George Hampton, C. M. Hanson, Jr., James W. Kitts, Chas. A. Lindgren, Harry S. MacManaman, Earl E. Nichols, Verne L. Peugh, Lewis H. Tuthill and George F. Wright. The author gratefully acknowledges this assistance which has been essential to the achievement.

Unusual opportunity in the study of concrete mixtures has been afforded the author since 1895, under the instruction, sponsorship or authority of Wm. Matteson, Loren M. Hunt, John F. Wallace, John F. Stevens, Geo. W. Goethals, Wm. L. Sibert, Harry H. Rousseau, Edgar Jadwin, Jerome Newman, Andrew J. Wiley, Chas. Derleth, Jr., Arthur P. Davis, and many others who have given valued support and encouragement.

Acknowledgments have been made, throughout the preceding chapters, to the world's workers in concrete mixture research during the past half century, whose contributions to knowledge of the physics of mixtures have been essential to this co-ordination of basic principles of concrete mixtures.

(*Finis*)

The Building Officials Conference of America will meet the week beginning April 23 at the Hotel Statler in Boston, Mass., in conjunction with the meeting of the New England Building Officials Conference.

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[1] August (1932) issue of CONCRETE, pages 10-12.

Concrete Masonry Gains Place in Federal Government Work

By H. B. EMERSON
Service Manager, Lehigh Portland Cement Company, Chicago, Ill.

CONCRETE masonry is now specified by practically every government department, as a result of the activities of the National Concrete Masonry Association and the Portland Cement Association. The former organization, in 1933, spent considerable time with the government departments, using to a great extent the book "Facts About Concrete Masonry" to convince officials that this product merited consideration along with the clay brick and clay tile specified for so many years.

In Federal Post-Office Buildings

One of the most important types of federal work, so far as products manufacturers are concerned, is post-office construction. While concrete masonry units are specified in this type of building for partitions, furring, and fireproofing units, these materials are not yet specified as backup. The many tests made on concrete masonry units justify this use, and work is continuing with the Treasury Department, which designs all post-offices, to obtain inclusion as backup in future work.

In the future there will be less of the monumental type of postoffice buildings and more of the practical type which will utilize, in many instances, face brick exteriors instead of limestone. This presents an opportunity for the concrete masonry manufacturer, inasmuch as one of the arguments that has always been used in Washington against concrete masonry units is that large units such as clay tile and concrete masonry were unsuitable for bonding the large limestone units used for facing. This development is being watched closely, and it is possible that before 1934 passes out of the picture hollow backup will be specified in backup construction by the Treasury Department.

Approved for Army Buildings

Specifications for U. S. Army construction work are wide open to concrete masonry units. If work of this type comes up and concrete units are not in the specifications, the omission is probably due to an oversight. The Quartermaster Corps has signified its intention of giving concrete units an equal opportunity with other masonry materials.

One point I want to get across to products manufacturers: Your Association and the Portland Cement Association have been successful in getting your products into specifications; but it is up to you to go out and sell the jobs. You are the point of contact on each individual job. You know the contractors. You know your own product, can figure the direct saving that its use will make over other types of construction in your community, and you can be responsible for this selling. A number of manufacturers are selling a sizable quantity of their units on government projects. The Haydite Corporation of Kansas City, recently sold 50,000 units for Fort Sill, and within the last month the same company has sold another order for some 20,000 units at Fort Riley, Kansas.

Government specifications are, perhaps, the hardest to crack of any in the United States today, and if it has been possible for products manufacturers to get in these rigid specifications it is not at all impossible for manufacturers to secure approval in practically any type of public works construction.

In State and Smaller Government Units

One Wisconsin manufacturer has sold block for basement foundation walls for some 52 country school houses under the CWA. Certainly this is a worth while improvement—one that not only makes the school house more livable but one that is permanent and that adds extra room to the buildings. Many localities are looking for public works jobs that will be of a permanent nature. Many have never thought of improving their country school houses, though the opportunity for additional sales of concrete masonry units is clearly seen.

Another public works job that commands attention was routed up by Harold Spaight, of the Cinder Block and Material Company, of Cedar Rapids, Iowa. This, again, was a job sold by using the book "Facts About Concrete Masonry," and using it intelligently. Spaight has obtained orders for some 250,000 concrete block and 335,000 concrete brick as a result of good salesmanship. Dont' think he had everything his own way in getting these orders. He had eleven clay competitors, and it was only by using incontrovertible facts that he was able to convince his local architects and the school board that his material would be suitable for the job.

Concrete Houses for the TVA

I have had the pleasure recently of seeing the plans for concrete houses developed by the Southern Cast Stone Co., of Knoxville, Tennessee. This is for the TVA in Tennessee. Two of these houses are being built, and there is a chance for several hundred complete houses. This prospect has not been developed by itself; it has developed from real salesmanship.

Low-cost dwellings, or apartments, especially in slum areas of cities, are developing very rapidly. It behooves products manufacturers to watch this market closely. Don't depend on someone else to sell for you. Get out and do it yourself.

The Portland Cement Association is receiving a list of all government buildings that come up for bids. They also get a list of successful bidders on these jobs. This information is being sent out to those products manufacturers who will follow the jobs. There is plenty of time

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Author's abstract of paper presented before annual meeting of Wisconsin Concrete Products Association, Milwaukee, Wis., February 9, 1934.

for you to sell the job after the successful contractor is named. Remember that you are in the specifications, and that your problem is a sales job only.

Government Specifications Must Be Met

There is one very important point to be remembered in selling federal jobs. Your product *must* meet government specifications. The blocks are tested, and a test failure makes the next sale that much harder. Quote prices intelligently and give complete data on the sizes of your units.

The products industry as a whole is not sales-minded. The Portland Cement Association has developed enough data over a period of years that, given proper study and use, every products manufacturer could be a real salesman. They can supply the leads, but it is up to the manufacturer to go out and sell. Take this literature they send you seriously—study it and profit by it; and above all things, support your own association.

Masonry Group of A. R. E. A. Presents Reports on Concrete

Many Phases of Concrete Design and Construction Discussed at Annual Meeting

THE thirty-fifth annual convention of the American Railway Engineering Association, held in Chicago on March 13 and 14, discussed several papers and committee reports of interest to the concrete construction industry.

With the exception of precast crossing slabs, covered in the report of the Committee on Grade Crossings, matters dealing with a broad scope of concrete construction were covered in the reports of the Committee on Masonry, headed by M. Hirschthal, of the D. L. & W. Ry., as chairman.

This committee and its various subcommittees reported progress on the subject of reinforced concrete arches. The report announces the intention of the committee to review the material presented in the current report and in previous reports, and to submit to the next annual meeting, for approval as recommended practice, specifications for the design and construction of reinforced concrete arches for railroad loadings.

Reports submitted by other subcommittees of the Committee on Masonry covered subject-matter such as drawings of a reinforced concrete trestle designed for E-60 loading, submitted for approval as recommended practice. Another subcommittee, in a report on progress in the science and art of concrete manufacture, presented a valuable contribution on high-frequency vibration in placement of concrete.

Centrally-mixed and transit-mixed concrete, foundations, specifications for lining railway tunnels with concrete, pneumatically projected concrete, design of expansion joints involving concrete and masonry structures, were some of the other subjects treated in the Masonry Committee report.

Copies of the "Report of Committee VIII on Masonry" are available in separate pamphlet form in limited quantity, and may be obtained, while they last, from the American Railway Engineering Association, 59 East Van Buren St., Chicago.

Georgia Cures Concrete Pavements with Cement Spray

Neat Cement Applied to Surface Just After Finishing—Forms Effective Seal

IN a paper presented before the thirteenth annual meeting of the Highway Research Board, held in December, Searcy B. Slack described a new method of sealing the surface of concrete pavement for curing, recently tried by the State Highway Board of Georgia. The surface of the pavement is sprayed just after finishing with a thin layer of neat cement paste. The theory is that the cement will seal the surface pores and retain the moisture necessary for curing.

Test sections using this method were compared with others using the standard wet earth curing and also where only 24-hour wet burlap was used. Strength comparisons were made on cores at 28 days and electrical resistance measurements were made to indicate the amount of moisture retained in the slabs by the different methods. Core strengths for earth and water cure were 3,388 p.s.i.; for cement spray, 2,981 p.s.i.; and for wet burlap, 2,716 p.s.i. The resistance tests showed good correlation with the strength tests and indicate that a resistance method of measuring moisture in concrete for curing has interesting possibilities.

Flagstones and Garden Ornaments in Century of Progress

MANUFACTURERS of ornamental concrete products, and contractors specializing in the placing of such work, will find particular interest in the 4½ acres of outdoor flower gardens at the 1934 *Century of Progress* exposition at Chicago. Flagstone walks and garden ornaments will constitute an interesting part of the display.

This view is from an actual photograph taken at the horticultural exhibit at A Century of Progress, Chicago, 1933

These gardens are being completely made over as a part of the exhibit of the horticultural department of *A Century of Progress*, in co-operation with garden clubs. It is expected to be one of the major centers of attraction of the 1934 Fair.

Highway Engineer Urges Year-Round Concrete Paving

H. F. Clemmer Describes Methods of Procedure—Field Tests Prove Concrete Paving Feasible in Winter—Specification for Cold-Weather Protection

CONCRETE pavement construction conducted while temperatures are near the freezing point requires special attention, not only to assure a reasonable rate of hydration of the cement, but to make certain that the moisture in the concrete will not freeze and cause permanent injury.

This is a part of a paper read before the annual meeting of the American Road Builders' Association in January, by H. F. Clemmer, engineer of materials, District of Columbia, on "Early-Strength Concrete—Effect of Temperature." This portion of Mr. Clemmer's paper, slightly condensed, deals with methods of placing concrete roads and street pavements during cold weather. In next month's issue D. S. MacBride, of the International Cement Corp., will discuss the Clemmer paper and will present additional methods of procedure on winter paving work.

The winter just closing is "water passed over the dam;" but progressive highway engineers will profit from both of these contributions when planning their paving programs for next winter. It is not too early to start thinking about those plans now.—Editor.

Field tests, however, have proved the practicability of providing the protection necessary for satisfactory "Winter Concrete Construction"—that is, for placing concrete when low temperatures prevail.

Realizing the importance of the temperature of concrete on the rate and degree of hydration of cement, the Highway Department of the District of Columbia requires that special precautions be taken whenever the temperature may reach 50 deg. F., or lower, during the 24 hours following the placing of the concrete.

Field tests have definitely established the conclusion indicated by the laboratory investigation, which showed the importance of placing concrete while the temperature is rising, unless special provisions are made for protection so as to maintain the temperature of the concrete.[1]

On one paving project where concrete placed when the temperature was as low as 14 deg. F. work was started at 7 A. M. Specimens were made from concrete mixed at 10 A. M. and from concrete mixed at 2 P. M. when the placing was stopped. The average 48-hour strength of the specimens made at 10 A. M. was 415 lb. per sq. in. and that of those specimens made at 2 P. M. was 286 lb. per sq. in., indicating that too little time had elapsed for the concrete placed in the afternoon to gain strength before the temperature started lowering. Six bags of cement per cubic yard of concrete and calcium chloride were used in the mix.

The hardening of concrete is a chemical reaction requiring heat and moisture. Any increase or decrease in the temperature causes an increase or decrease respectively in the rate of hardening of the concrete. Should the temperature of the concrete become so low that the chemical action is entirely stopped, considerable time and increase in temperature is required to start the hydration process again.

During the summer months the important problem in curing is to maintain sufficient moisture in the concrete for maximum hydration of the cement, but during the winter months the problem is to maintain the temperature of the concrete sufficiently high that maximum hydration may be obtained.

Speed Up Rate of Hardening

It is, therefore, important to speed up the setting of the cement to every practicable extent in order to reduce the length of time necessary for the use of coverings or other means for maintaining a temperature satisfactory for hydration. Calcium chloride incorporated in the concrete mix has been shown to be of particular value for accelerating the setting of cement and as an agent to insure moisture for satisfactory curing.

In considering the effect of calcium chloride as an accelerator of the setting of cement it is interesting to note results of studies reported by the U. S. Bureau of Standards. It will be seen that the maximum temperature of the cement paste with varying percentages of calcium chloride are approximately the same; the time in which these maximum temperatures is attained is materially reduced by the addition of calcium chloride. This increase in the rate of temperature rise increases the rate of hydration of the cement, and, therefore, the early strength of the concrete.

Calcium chloride in the concrete mix does lower the freezing point of the mixing water; however, the amount recommended for use as an accelerator is not sufficient to be of particular importance in this regard. The value of calcium chloride in concrete is its accelerating action on the hydration of the cement.

Use of High-Early-Strength Cement

The use of high-early-strength cement is of considerable value in overcoming the effect of low temperature, due to its rapid rate of hydration, and its use in place of standard portland cement and calcium chloride or of additional standard portland cement and calcium chloride is a matter for economic consideration. The use of high-early-strength cement together with calcium chloride produces very marked results in the early strength of concrete even when it is placed at very low temperatures and without special protection.

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[1] How this protection has been provided in a number of cases will be told in the May issue of CONCRETE, in an article by D. S. MacBride.—Editor.

When temperatures at the time of placing concrete are near freezing and remain low the use of either high-early-strength cement or calcium chloride or both must not be entirely relied upon to insure proper setting of the concrete. Temporary enclosures heated with salamanders or the covering of pavements, sidewalks, etc., with at least a 6-in. layer of straw uniformly distributed and held in place by canvas or burlap, must be provided.

Heat Water and Aggregates

Heating of the mixing water is effective in raising the temperature of the concrete, as is also the heating of the aggregates. Whenever freezing temperatures prevail the aggregates themselves are likely to be frozen and must be heated to insure against the incorporation of lumps of frozen material in the mix. A further application of heat than is necessary to thaw out or prevent these materials from freezing will be of very definite value in increasing the temperature of the aggregates, and of the concrete.

Specification for Cold-Weather Protection

Following are the specifications for the cold-weather protection of concrete as insured by the Highway Department of the District of Columbia:

"Whenever the temperature may reach 50 deg. F. or lower, during the 24 hours following the placing of the concrete, calcium chloride incorporated in the concrete mix shall be used for curing of the concrete, in lieu of whatever method of curing is being used. The cost of the calcium chloride, and its use, shall be included in the bid price per square yard of pavement.

"Whenever the temperature may reach 32 deg. F., or lower, during the 24 hours following the placing of the concrete, the surface of the pavement shall be covered with hay, straw, or other material approved and as directed by the engineer, for at least 3 days.

"Heating of aggregates may be required during the prolonged periods of freezing temperature, or lower.

"Preparation and use of calcium chloride shall be as follows: Place one bag (100 lb.) of calcium chloride in a barrel and add sufficient water to make a solution of 25 gallons(one-half barrel). This solution should be stirred to be sure the calcium chloride is completely dissolved.

"An amount (1½ to 2 qts.) as directed by the engineer shall be added to the concrete mix for each bag of cement. The quantity of mixing water shall be reduced by the amount of calcium chloride solution used. The method of incorporating the solution into the concrete mix shall be approved by the engineer."

If the Public Works program is to be a success it is imperative that everyone in charge of construction realize the importance of keeping each project working to the maximum. Year-round concrete construction is one of the greatest factors in this success. That construction is practicable in cold weather, if consideration is given to the protection necessary during the curing period of the cement, has been fully demonstrated by actual practice.

Not only is it worth while giving particular consideration to year-round highway construction on account of immediate labor conditions, but continuance of construction work the year round is a most important factor affecting permanent prosperity.

Measure and Draw Plans of Old Public Buildings

Employ Architects and Engineers to Compile Valuable Records

A PROJECT recently started in Newton, Massachusetts (population approximating 65,000) promises to develop useful temporary employment for many architectural and engineering draftsmen, if local organizations representing these groups will promote similar plans in their respective cities.

The city of Newton owns about 100 buildings (schools, fire-engine houses, libraries, police stations, stables, and playground buildings). Many of these buildings are more than 50 years old, and—except in the case of very recent buildings—no plans of the structures remain in existence.

The purpose of the new project is to supply such plans. The lack of plans necessitates repeated visits to the buildings, and the taking of measurements, whenever any information concerning them is required. In the event of fire loss, no record is on hand from which to make appraisals.

Architectural and engineering draftsmen are now being given much needed employment in making measurements and preparing plans of these city-owned buildings. When completed, the plans will be photostatted down to uniform size, and bound in folders, which will also contain a photograph of each elevation, a brief specification of the construction, and a description of the mechanical equipment.

The records being compiled will be of great value to the city, for, as previously stated, they will save must needless traveling week by week, and they will supply invaluable information in case of fire and for appraisal purposes.

Harry A. Hageman, city building commissioner, obtained approval of this work as a CWA project, the city having appropriated $900 for materials. The work is in direct charge of Leslie H. Allen, formerly with the Aberthaw Company.

Although this work is being carried through as a CWA project, the records obtained are so valuable that similar work might well be promoted in all cities having public buildings for which plans are not now available, regardless of whether the project is financed by the city or government aid.

High Elastic Limit Steel as Concrete Reinforcement

Committee of Highway Research Board Recommends Working Stresses of 25,000 to 30,000 Lb.

A REPORT presented at the December annual meeting of the Highway Research Board by H. J. Gilkey, chairman of the project committee of the H. R. B. and professor of theoretical and applied mechanics at Iowa State College, describes a preliminary investigation of high elastic limit steel as concrete reinforcement in concrete roads, street pavements, and in reinforced concrete structures.

This investigation has been conducted under the joint auspices of the Highway Research Board and the engineering experiment station of Iowa State College, by George C. Ernst, special research assistant.

In the search for improvement or economy in engineering structures the use of high elastic limit steels as reinforcement in concrete is one of the problems meriting and demanding investigation. Many questions have arisen relative to the use of this type of reinforcement. The report reviews prior investigations which throw light upon the questions, and it also gives the results of this preliminary investigation, which covers the following points:

- A. A study of the design aspects of higher working stresses.
  - 1. Economical stresses.
  - 2. Possible effect on deflection.
- B. Practical use of higher working stresses in design.
  - 1. Choice of specifications.
  - 2. Choice of design diagrams.
  - 3. Redesign of a deck girder highway bridge.
  - 4. Design of columns.
- C. Possible economies of high elastic limit reinforcement.
  - 1. Quantity of material.
  - 2. Formwork cost.
  - 3. Increased cost of higher strength materials.

It is concluded that high elastic limit steel reinforcement is satisfactory with a working stress of 25,000 or 30,000 p.s.i., and that it has advantages in load-carrying capacity and in economy of design and construction.

The report includes an outline of future investigations needed. There is also a bibliography.

Types of Crack Fillers Studied by Highway Department

W. H. ROOT, of the Iowa State Highway Commission, in a paper read before the thirteenth annual meeting of the Highway Research Board in Washington, in December, presented a record of the conditions of application and the results obtained with various fillers on three experimental road sections in Iowa. In 1931 five asphalts, three tars, one asphalt cut-back and one asphalt emulsion were tried on one road. In 1932 materials similar to the more successful asphalts and tars used in 1931, and a heavier cut-back asphalt, were used on two other roads.

The cut-back and the emulsion used in 1931 gave some trouble in application and neither appeared to solidify rapidly enough to be considered satisfactory for use under traffic. The heavier emulsion gave satisfaction, although it was difficult to apply. The asphalts with penetration around 100 at 25 deg. C. and fairly soft tars with a float test around 112 gave good results.

The results of similar experiments in California and Connecticut are to be reported later.

Beautifying Our Highways

IN his address before the annual meeting of the American Road Builders' Association in January, Thomas H. MacDonald, chief of the U. S. Bureau of Public Roads, stressed the importance of paying attention to the beautification of our highways. Scars left by construction operations should be eradicated, through grading, seeding and well-designed planting.

The illustration shows what the California Division of Highways is doing in this respect. The spot here pictured is on State Route 37, between Gold Run and Airport, built in 1933. A culvert has been beautified and the brook flowing through it has been made accessible to the halting motorist. For the illustration, CONCRETE is indebted to *California Highways and Public Works Magazine.*

California highway culvert beautified and brook made accessible

WHEELS, WHEELS, WHEELS! 83 Million of 'em
—and a Slab of 24-Hour Concrete

Pounded by Six-Years' Traffic on Nation's Busiest Highway, 'Incor' Concrete in Perfect Condition

Back in 1928, shortly after 'Incor' 24-Hour Cement was first introduced, a Boston Post Road repaving job reached the heavily-traveled Main and Echo Avenue intersection, New Rochelle, N. Y. This road carries the bulk of passenger and truck traffic between New York, its suburbs and New England,—20,000 vehicles a day.

To reduce detour time, 'Incor' was used for half of the intersection. First important 'Incor' job in the New York area, engineers watched with critical eye. Yes, without question, it was gaining strength rapidly—but could it carry full traffic load in a single day?

Cylinders were tested at 24 hours; 10 minutes later barriers were down, the highway opened. Two hours later, a 30-ton steam shovel on a 10-ton carrier passed over the new concrete!

Pounded by 83 Million Wheels!

Three years later, cores of 'Incor' and of same-age ordinary Portland cement concrete were cut and tested. 'Incor' averaged 6417 pounds per sq. in., ordinary cement 5516. Last March the photograph (at the right) was made with an ordinary camera. It shows as pretty a slab of concrete as anyone would want to look at. Pounded by ceaseless traffic, 10,000 cars a day for 5 years and 8 months—83,000,000 wheels, if the slide-rule didn't slip!

'Incor' makes better concrete because it is better cement—it has to be a better-quality cement to harden in 24 hours. Hardening in one-fifth to one-seventh of the time required by ordinary Portland, 'Incor' now makes it possible to eliminate highway detours and avoid business losses caused by long-closed traffic arteries.

In concrete buildings, column forms are stripped first morning after concreting, floor forms that afternoon; one form-set does the work of several, reducing form and handling costs; financing expense reduced, revenue from investment begins sooner.

The price of 'Incor' is now only little more than ordinary Portland Cement—a fraction of resulting economies. 'Incor'* is made by the producers of Lone Star Cement, subsidiaries of International Cement Corporation, New York, and is sold by other leading cement manufacturers.

* Reg. U. S. Pat. Off.

'INCOR' 24-Hour Cement

HOW TO DO IT

✦ Questions and Answers ✦
Consultation and Comment

A department devoted to the solution of problems encountered in concrete work. Readers are welcome to add to or improve upon the suggestions printed and to submit their views for possible publication.

Placing Mortar Coating on Old Concrete Floor

I have made several attempts to place a new cement mortar on an old smoothly troweled concrete floor in a warehouse, but the coating will not stick to the surface. Can you suggest a method that might succeed?—A. G. D., Beatrice, Nebraska.

The smoothly troweled surface of the old floor is probably the main source of your difficulty. It is also quite probable that dirt (and perhaps some oil) has been ground into the surface. In that case you will probably do this work at the least expenditure of labor by roughening the present surface by means of a tool similar to those used for bush-hammering exposed surfaces of concrete. After the bush-hammering is completed, all loose material should be brushed off and then wetted. Just in advance of the new coat of mortar the wetted surface should be brushed with a coat of neat cement grout (a mixture of cement and water) about the consistency of thick cream.

Through the removal of the present surface of the old floor, by means of the bush-hammering tool or some similar device, several advantages are gained. In place of the old smoothly troweled surface you will have a fresh, roughened surface. In addition, most of the dirt and oil in the old floor surface will be removed in the bush-hammering process.

If parts of the floor still continue to show oil stains, the oil can be removed by one of the methods described on this page in former issues of CONCRETE, particularly in those of December, 1931, page 30, and January, 1932, page 30.

Possible Heights of Reinforced Concrete Towers

In your issue of February, 1934, on page 24, reference is made to a tower of reinforced concrete which the designer proposes to build to a height of 2,300 ft. as a feature of the Universal Exposition to be held in Paris in 1937.

Can you refer me to any analysis of heights to which high towers of reinforced concrete construction can be built without having the allowable working stress exceeded because of dead weight and wind pressure?—R. A. S., Chicago, Ill.

A staff article in the December (1933) number of *Ferro-Concrete* (London) quotes some notes communicated to that publication by Henri Lossier, the well-known French engineer, in which he analyzes this problem, for lightly reinforced and for heavily reinforced concrete tower structures.

In the analysis it is assumed that by utilizing carefully selected and graded aggregates and cement of high strength, and placing the concrete under high-frequency vibration, an average 90-day crushing strength of 8,500 lb. per sq. in. may be attained. It is further assumed that heavily reinforced concrete structural members can be made to attain a 90-day crushing strength of 17,000 lb. per sq. in. over the gross cross-sectional area. Working stresses are taken at 0.36 of the crushing strength at the age of 90 days.

Wind pressure is assumed at 50 lb. per sq. ft. at an altitude of 327 ft., 70 lb. at an altitude of 1,300 ft., and increasing (though not quite in a straight line) to the assumed value of 140 lb. per sq. ft. at an altitude of 32,700 ft.

On the basis of these assumptions and working stresses, there is a definite height at which the actual stress becomes equal to the safe working stress.

For a walled tower of pyramidal form, Lossier finds that this practical limit of height is approximately 4,500 ft. for concrete with light reinforcement, and 8,500 ft. for heavily reinforced concrete.

For rigid-frame towers, Lossier finds the practical limit of height at 8,000 ft. for lightly reinforced concrete and 20,000 ft. for heavily reinforced concrete. He estimates, further, that the lightly reinforced concrete tower would be the most economical up to a height of about 3,300 ft. For heights ranging from 3,300 to 7,000 ft., heavily reinforced concrete would be the most economical. For towers exceeding 7,000 ft. in height, Lossier believes special high-tension structural steel might cost less than heavily reinforced concrete.

Lossier has elaborated a design for a proposed reinforced concrete tower 4,000 ft. high.

Porous Concrete Well Casings

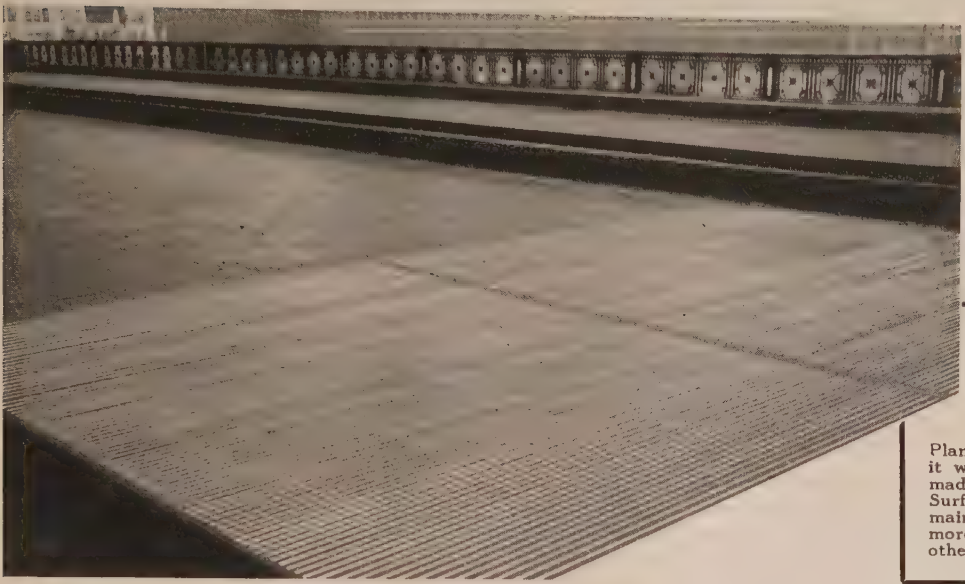
What proportions should be used in making concrete for well casings, in order to have it sufficiently porous to admit water readily from water-bearing soil?—D. E. L., Manhattan, Kans.

Regarding actual proportions, this will vary with the nature of the aggregates available; but, in general, the finer particles of sand must be omitted from the mixture. It is best to make up several samples of aggregate for experimentation, in one case screening out and discarding all sand passing the No. 16 screen, in another case omitting all sand passing the No. 8 screen and a third, all sand passing the No. 4 screen.

Then obtain bottomless metal cylinders or boxes—6 by 12- in. or 8 by 16-in. concrete test cylinders would be satisfactory—and fill the bottom part of the cylinders with concrete made from each of the sample aggregates. The concrete in the cylinders should have a depth equal to the proposed thickness of the well casing. After the concrete has hardened, measured quantities of water poured into the cylinders will demonstrate the relative porosity.

Well casings are also made with precast concrete units, curved to a given radius and provided with tongues and grooves. Such units are set up without mortar. As with monolithic concrete casings, the best proportions to use should be determined by experiment.

SERVICISED
EXPANSION JOINTS



SPONGE RUBBER
CORK
FELT SIDED
PLAIN
COMPOSITION

BRIDGE PLANKING PROTECTION COURSE

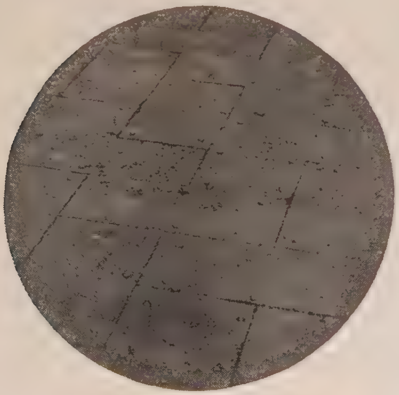
SERVICISED Bridge Planking has now been in use for more than seven years! No SERVICISED Planking has ever been replaced where it was recommended for the job. It is made in Standard, Sementread and Rock Surfaced styles and is in use on the main Chicago bridges where probably more traffic is encountered than on any other thoroughfare.

ASPHALT PLANKING

STANDARD—SEMENTREAD
ROCK SURFACED

SEMENTREAD is a new skid-proof planking—one which can be **guaranteed skid-proof**—when laid horizontal to the traffic it promptly stops the forward motion of the car, and when laid vertical to the traffic it stops the side skid as well as forward skidding. SEMENTREAD comprises a cement rib keyed in the asphalt plank surface, which adds rigidly to the surface also making it skid-proof. This material is especially adapted on city bridges and viaducts where wet days are a menace to traffic and where short skids are dangerous and cause accidents. **Be sure to learn about this product before laying another foot of planking!**

Skid-Proof Your Bridges



Rock Surfaced Planking

ROCK SURFACED planking comprises SERVICISED asphalt planking having imbedded in its surface particles of rock. We do not believe that this is in any measure as skid-proof as SEMENTREAD. It, however, prevents skidding to a greater extent than the plain surfaced asphalt planking.

CENTER ROAD MARKINGS

SEMENTREAD planking in six or eight inch widths is highly adapted for road marking purposes having alternate black and white or black and yellow lines—the lines consisting of Portland cement.

SERVICISED Expansion Joints, whether sponge rubber, cork, felt sided, or plain composition, excel! SERVICISED Expansion Joints have given service over a period of twelve years, and are found in State highway work in every State in the Union which has used Expansion Joint within this period. You will not be doing justice to your organization without securing prices and learning about these products.

Write today for full particulars on SERVICISED Products

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6051 WEST 65th STREET, CHICAGO

Coming Conventions

***April 19*—National Safety Council. Eleventh Annual Safety Engineering Conference. Pittsburgh, Pa.**

***April 23*—Building Officials Conference of America. Hotel Statler, Boston. Wm. F. Hurd, Secretary, Room 203 City Hall, Indianapolis, Ind.**

***April 30-May 1*—National Safety Council. New England Safety Conference. Boston, Mass.**

***May 14-17*—National Fire Protection Association Meeting. Atlantic City. Robert S. Moulton, Technical Secretary, 60 Batterymarch Street, Boston, Mass.**

***June 25-29*—American Society for Testing Materials. Annual. Chalfonte-Haddon Hall, Atlantic City, N. J.**

***July*—The National Terrazzo and Mosaic Association. 1934 Convention. Toronto. J. M. Fuhrman, Secretary and Treasurer, 524 Brook St., Louisville, Ky.**

Construction Work Shows Big Increase

March Reports Great Advance Over February and Over March of Year Ago

CONTRACTS awarded for all classes of construction in the 37 states east of the Rockies during the initial half of March reached a total within 4 per cent of the volume reported during the entire month of February, according to figures of F. W. Dodge Corporation. Construction awards in the first 15 days of March, totaling $92,521,800, were larger by 55 per cent than the total reported for the entire month of March, 1933. Although the increases over last year were due chiefly to larger governmental undertakings, the Dodge bulletin indicates a moderate gain in privately-financed construction projects as well.

Ready-Mixed Concrete Code Approved

THE code of fair competition for the ready-mixed concrete industry was approved on February 28.

The code fixes a basic maximum work-week of 40 hours and a basic minimum wage of 35 cents an hour in the South, 45 cents an hour in the North, 40 cents an hour in the intermediate area, and 50 cents an hour in New York City, with a decreasing scale of five to ten cents an hour in cities ranging from 500,000 population down to 75,000 population, and for cities of less than 75,000 population. About 7,500 persons are employed in the industry.

F. C. Brown, business consultant, Washington, D. C., has been appointed as Administration Member of the Code Authorities of the ready-mixed concrete industry and also the concrete masonry industry.

Code Authority Headquarters

THE CODE AUTHORITY for the Reinforcing Materials Fabricating Industry has established its office at 201 North Wells Street, Chicago, Illinois, with R. W. Johnson as secretary. Incidentally, the building at this address, a structure twenty-nine stories high, is said to be the tallest building in the United States having a structural frame of reinforced concrete.

Construction Industry Organizes. With its membership officially approved by NRA, the General Contractors' Divisional Code Authority, set up under chapter two of the code of fair competition for the construction industry, met in Washington early in March to perfect arrangements for registering every general contractor in the country and launching active administration of the code on March 19, its effective date.

Headquarters for the General Contractors' Divisional Code Authority have been established at the Munsey Building, Washington, D. C.

From the Patent Office

By J. KAPLAN
Patent Attorney, Washington, D. C.

Joint for concrete road: Walter S. Edge, Pittsburgh, Pennsylvania. U. S. Pat. 1,926,516, Sept. 12, 1933.—This joint is formed by cleaving the concrete slab along a predetermined line and simultaneously smoothing the walls of the joint while the concrete is still plastic. A cold liquid filling material is then poured into the joint.

●

Agitating ready-mixed concrete: Edward A. Hoffmann, Reading Pennsylvania. U. S. Pat. 1,926,623, Sept. 12, 1933.—Ready-mixed concrete transported in a truck with an agitator body is kept conditioned by subjecting it to a combined slow rolling and flowing motion which also expels entrained air from the mixture.

●

Interlocking concrete face brick: Frank E. Clark, Bridgeport, Connecticut. U. S. Pat. 1,947,188, Feb. 13, 1934.—This concrete face brick displaces six bricks of standard size. The unit has interlocking features and may be laid up to produce either a hollow or a solid wall. Economy is claimed as a distinct additional advantage.

●

Cementing well casing: Charles R. Edwards and Oscar Codier, Houston, Tex. U. S. Pat. 1,934,701, Nov. 14, 1933.—This process of cementing casing into a well, under water, comprises transporting hydraulic cement in a dry state, and carrying embedded in the cement a frangible receptacle containing a set-accelerating agent. When lowered to the level where cementing is to be done, the cement is released, the receptacle is broken, and the mixture, being under water, forms a quick-setting paste.

●

Bending metal bars: Friedrich Schlagintweit, Baden-Baden, Germany. U. S. Pat. 1,933,189.—The machine comprises two parallel sleeves, each permitting the passage of one bar. Coiling rollers driven by gearing are carried eccentrically at the ends of these sleeves.

●

Making and hardening concrete pipe: Manabu Tada, Tokyo, Japan. U. S. Pat. 1,932,150, Oct. 24, 1933.—While the concrete is still plastic and in the molds it is subjected to an atmosphere of CO_2, for the purpose of effecting a surface hardening sufficient to permit immediate removal of the molds.

●

Art marble or stone: Herman Ziegler, Maspeth, N. Y. U. S. Pat. 1,935,535, Nov. 14, 1933.—Artificial marble is produced by subjecting a supply of cement in a substantially liquid state to the action of air under pressure, by blowing the air on the top of the soft cement, after which the cement is allowed to cure in air under ordinary atmospheric pressure.

●

Art stone and method of manufacture: Hynek Oberherr, Cleveland, Ohio. U. S. Pat. 1,935,985, Nov. 21, 1933.—This invention comprises an artificial stone resembling marble, having a body portion formed of chalk and portland cement, and a polished surface formed of a layer of oxalate crystals, fluoride and waterglass.

PENNSYLVANIA:

• 13 years' experience

WHILE Pennsylvania is but one in the procession of states in which Calcium Chloride is an officially approved method of concrete curing, these statements (made in 1931) by engineers of its Highway Department are typical of reports made wherever experience has had opportunity to speak:

> "The Pennsylvania Department of Highways has used the Calcium Chloride admixture method of curing for ten years, the last six as an alternate to wet earth or straw. This method has grown in popularity until at the present time more than 95% of our concrete roads are cured in this manner.
>
> "From strength tests, examination of road surfaces, crack surveys, drilled cores, examination of reinforcing, we are convinced that under our conditions this method is a satisfactory alternate method of curing and gives us the advantage of *higher early strength with a resulting advantage of earlier opening of pavement to traffic.*"

THE ECONOMIES of Calcium Chloride curing are obvious and decisive: No costly covering of earth or straw; no long stretches of piping for water supply; no repeated wetting and supervision day after day; no heavy waste or expensive removal of cover materials and accessories.

THE RESULTS of Calcium Chloride are equal to, and in many respects far better than, those from any other method: Calcium Chloride assures an even, controlled hydration of the slab; cures uniformly; minimizes volume changes; accelerates the set (increases 48-hour strength by 30% or more).

THE ADVANTAGES: To the public—early opening of highway to traffic; early elimination of the inconvenience and wear-and-tear on vehicles from bumpy detours. To the contractor—faster operation; fewer chances of bad-weather delays; a quick clean-up and early availability of equipment for the next job.

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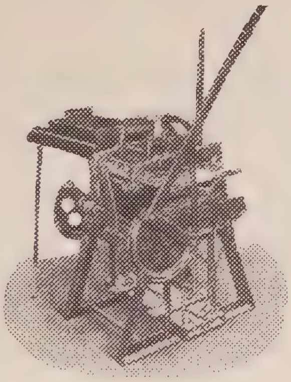

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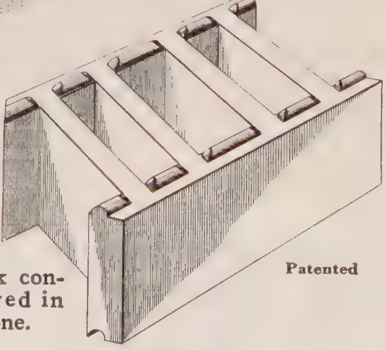

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New Books and Pamphlets

Reinforced Concrete Design

REINFORCED CONCRETE—MECHANICS AND DESIGN, by Robert A. Caughey, Professor of Structural Engineering, Iowa State College. For sale by Iowa State College Book Store, Ames, Iowa. Stiff paper cover, 160 pages, 8½ x 11 in. Numerous design charts, drawings, tables and plates. Price $2.70.

This manual has been written for the primary purpose of providing a textbook in the mechanics and design of reinforced concrete. It meets the requirements of the student as well as practicing structural engineers who, though conversant with methods of routine design, desire a more complete knowledge of design principles so necessary to the solution of unusual problems.

In addition to the treatment of structural members of buildings, the book includes chapters on composite members of concrete and structural steel, design of arches and rigid frames, design of masonry dams, and design of retaining walls.

Wheel Loads on Highways

WHO SHALL USE THE HIGHWAYS, AND HOW, is the title of a 16-page illustrated pamphlet published by the American Association of State Highway Officials, 1222 National Press Building, Washington, D. C.

This booklet is concerned mainly with a study of size limits and wheel-load limits for highway transport units. States are urged to adopt uniform regulations. The proposed standards are more conservative than the loads now permitted by many states. Limits recommended are 35 ft. in length for single units, 45 ft. as the combined length of two units, height 12½ ft., and width 8 ft. Wheel loads shall not exceed 8,000 and 9,000 lb. on high and low-pressure pneumatic tires, respectively.

Railroad interests are severely criticized for their efforts to dictate rules for highway transport.

Copies of this booklet should be in the hands of all state highway officials and state legislators.

Early-Strength Concrete in Road Construction

EARLY-STRENGTH CONCRETE—EFFECT OF TEMPERATURE, by H. F. Clemmer, is the title of a 16-page, 6 by 9-in. booklet published as Bulletin No. 42 by the American Road Builders' Association.

The booklet contains valuable information on all-year concrete highway construction, the information being based on the results of laboratory and field investigations carried on in Washington, D. C. Copies of the booklet may be obtained, on request, from the Calcium Chloride Association, 2075 Penobscot Building, Detroit, Michigan.

Cement-Bound Macadam Specification

SPECIFICATION FOR CEMENT-BOUND MACADAM PAVEMENT is the title of an 8-page printed bulletin, 7½ by 10 in., issued by the Portland Cement Association, 33 W. Grand Ave., Chicago, Illinois.

This specification, printed in this separate form for the convenience of highway engineers, has been revised in the light of information developed as a result of the construction of the experimental road of cement-bound macadam at Elmhurst, Illinois, in 1933.

ORGANIZATIONS

American Association of State Highway Officials; W. C. Markham, Executive Secretary, 1222-24 National Press Building, Washington, D. C.

American Chemical Society, Mills Building, Washington, D. C.

American Concrete Institute; Harvey Whipple, Secretary, 7400 Second Blvd., Detroit, Mich. Thirtieth annual convention, February 20-22, Royal York Hotel, Toronto, Canada.

American Concrete Pipe Association; M. W. Loving, Secretary, 33 West Grand Ave., Chicago.

American Institute of Chemical Engineers, Bellevue Court Bldg., Philadelphia, Pa.

American Railway Engineering Association; E. H. Fritch, Secretary, 59 East Van Buren St., Chicago, Ill.

American Road Builders' Association; Chas. Upham, Engineer-Director, National Press Building, Washington, D. C.

American Society of Civil Engineers; Geo. T. Seabury, Secretary, 33 West Thirty-Ninth St., New York City.

American Society for Testing Materials; C. L. Warwick, Secretary-Treasurer, 260 S. Broad St., Philadelphia, Pa.

Associated General Contractors of America; E. J. Harding, Managing Director, 222 Munsey Bldg., Washington, D. C.

Building Officials Conference of America; Wm. F. Hurd, Secretary, Room 203, City Hall, Indianapolis, Ind.

Cast Stone Institute; L. A. Falco, Secretary, Chapel St. and Blatchley Ave., New Haven, Conn.

Cement Institute; H. C. Lundborg, General Manager, 11 East 44th St., New York City.

Concrete Reinforcing Steel Institute; R. W. Johnson, Secretary, 333 North Michigan Ave., Chicago, Ill.

Engineering Institute of Canada; 2050 Mansfield St., Montreal, Quebec.

Highway Research Board; Roy W. Crum, Director, 2101 Constitution Ave., Washington, D. C.

Joint Committee on Standard Specifications for Concrete and Reinforced Concrete; F. R. McMillan, Secretary, 33 West Grand Ave., Chicago.

National Board of Fire Underwriters; W. E. Mallalieu, General Manager, 85 John St., New York City.

National Concrete Burial Vault Association; J. H. Stuart, Secretary-Treasurer, Bremen, Ohio.

National Concrete Masonry Association; Horace W. Bush, Secretary and Treasurer, 211 Edgemont Place, Teaneck, N. J.

National Crushed Stone Association; J. R. Boyd, Secretary, 1735 14th Street, N. W., Washington, D. C.

National Fire Protection Association; Franklin H. Wentworth, Managing Director, 60 Batterymarch St., Boston, Mass.

National Lime Association; Norman G. Hough, Secretary and Manager, 927 Fifteenth St., N. W., Washington, D. C.

National Ready-Mixed Concrete Association; V. P. Ahearn, Secretary, 545 Munsey Bldg., Washington, D. C.

National Sand and Gravel Association; V. P. Ahearn, Executive Secretary, 545 Munsey Bldg., Washington, D. C.

National Slag Association; H. J. Love, Secretary-Treasurer, 1449 Leader Bldg., Cleveland, Ohio.

National Terrazzo and Mosaic Association; J. M. Fuhrman, Secretary-Treasurer, 524 Brook Street, Louisville, Ky.

New Jersey State Concrete Products Association; Horace W. Bush, President, Lyndhurst, N. J.

Portland Cement Association; Edward J. Mehren, President; William M. Kinney, General Manager, 33 West Grand Ave., Chicago.

Rail Steel Bar Association; H. P. Bigler, Engineering Secretary; Builders' Bldg., 228 N. La Salle St., Chicago, Ill.

Wire Reinforcement Institute; R. D. Bradbury, Director, National Press Bldg., Washington, D. C.

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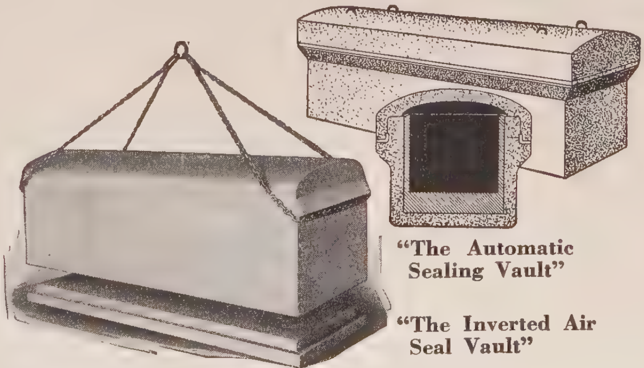

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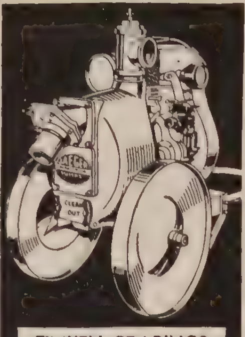

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Equipment and Materials

THE Blaw-Knox Company of Pittsburgh has developed for the 1934 construction season a road finisher for concrete and bituminous paving which is fully electrically powered, power being furnished by a generator direct connected to a gas engine, mounted on the machine.

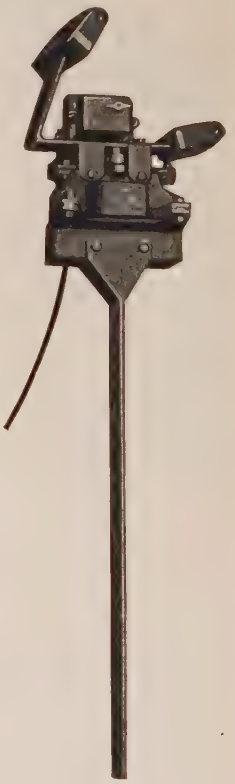
Before placing this machine on the market, they claim it was tested and proved on four paving projects, totaling twenty miles, in connection with which it proved its ability to build ribbon smooth roads speedily and economically. An electric drive permits greater ease of operation. It has finger touch control without exertion of any particular effort on the part of the operator, who is now able to devote his time to better finishing, rather than to the mechanics of machine control.

The new Blaw-Knox gas-electric finisher has four speeds forward and reverse. Traction is now equal on all four wheels, and maximum grades under a full load can be covered with ease.

The machine is equipped with automatic brakes, which hold the finisher on all grades. It has electric connections for floodlighting for night work, with ample reserve power, which can be used for operating tools if necessary. It is equipped with roller bearings and is bronze bushed throughout. It is designed for addition of vibrating attachments, tamper, and accessories for bituminous paving.

•

A NEW internal vibrator is illustrated and described in a recent folder by the Syntron Company of Pittsburgh. This vibrator, with a speed of 3,600 vibrations per minute, 110 volt, A. C., is designed for settling concrete in flat slab construction, according to the manufacturers, the spud reaching down through the mass and vibrating the forms underneath, the reinforcing and the mass itself. They say it is especially adaptable for vibrating down around girders in floor construction as the thin, steel blade spud can easily get in between the beam and the form.



The Syntron internal vibrator

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EMBECO is an aggregate said to contain a metallic ingredient which counteracts shrinkage of setting concrete, thus producing a perfect, level bearing surface. This metallic element contributes the "give and take" ductility—an important factor in the life of the job. It is the product of the Master-Builders Company, Cleveland, Ohio.

•

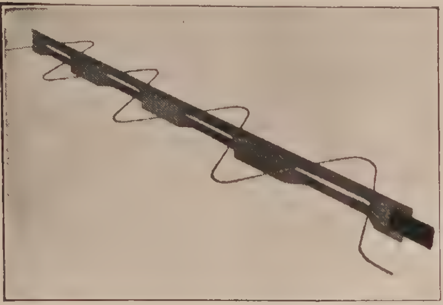
THE Loxit system for laying floors employs a metal channel 1⅛-in. wide by 5/16-in. high with overlapping top edges, to be laid over the sub floor in the same general manner as the old-fashioned wood sleepers. The channels are laid 12 or 16-in. o. c.—the ends are lapped (not butted)—leveled, and fastened directly to the concrete slab. The wood flooring is then laid in the usual way with a specially designed clip to be slipped into the channel by the carpenter immediately ahead of the last board. As the carpenter drives up the next board, the clips are driven into place. Driving up the next board forces the clips to bite into and over the tongue of one board and embed themselves in the groove of the other, thus securely locking both boards together and to the channel. The tongues of the clips are slotted so that they may easily adjust themselves to the tongue and groove of the flooring. They are made slightly wider at the bottom than the channels, thereby assuring a tight gripping contact.

The Loxit system is said to be especially suitable for laying floors over concrete slab construction.

Equipment and Materials

METAL-LACED JOINT is the name of a new closed joint for concrete roads, just announced by the A. O. Smith Corporation, Milwaukee.

The principle of design, according to the manufacturer, involves a vertical plate through which is threaded a zig-zag steel rod. No stakes or supports are required. The plate is shaped so as to provide a very efficient slab interlock or transfer of load vertically, while the zig-zag rod serves to "lace" the slabs together. The joint is mathematically proportioned to use every pound of metal in an efficient manner. Incidentally, this joint furnishes a desirable steel reinforcement of the slabs for 10 inches along adjoining sides.



Smith Metal-Laced Joint for concrete roads

"Metal-Laced Joint" is produced in standard 10-foot units, and designs are available for both longitudinal and transverse joints.

●

FLEX-PLANE and Trail-Plane are devices said to economically install contraction joints—premolded material ¼ or ⅜-in. thick, removable V-plate, moulding strips for poured joint, or the company's own Seal-Flex asphaltic ribbon joints. These machines, manufactured by the Flexible Road Joint Machine Company, Warren, Ohio, can be pulled by the finishing machine, or equipped with hand traction. Catalog L-5 describes them fully.

●

TYPE "F" pump, for unloading bulk cement from hopper bottom cars or for transporting cement from L. C. L. containers or box cars, where electricity is not available, is recommended by the Fuller Company, Catasauqua, Pa. They claim this pump is capable of transporting cement over distances beyond the economical limits of mechanical conveyors. It is simple, easily installed and operated by common labor, they say.

●

JOLTCRETE, Jr., is a new machine offered by Joltcrete, Inc., Yonkers, N. Y., with a new method of block making—the wet mass is jolted into the molds and almost immediately the finished product is stripped. The machine is said to be a complete power plant and turns out all sized blocks, including ashlar, both random and coursed. The rapid action of the jolting (3,500 blows per minute) tends to give the concrete a kneading action.

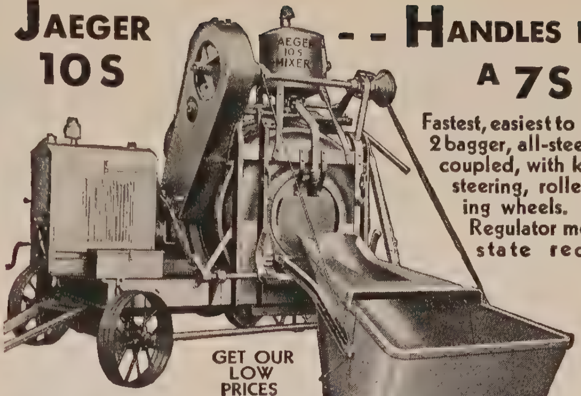
●

MINERAL-SURFACED asphalt bridge plank, as offered by Johns-Manville, New York City, is said to withstand considerable vibration and deflection, to be strong, durable and to knit and heal under traffic. They also claim greatly improved traction when wet.

It is easily applied with simple tools and local workmen. Specifications for application over concrete decks are ready for distribution.

●

NU-INTERLOCKING brick block construction and machinery has been patented by the Bridgeport Stone Company of Bridgeport, Conn. These blocks, finished in any color, are designed for solid or hollow walls and for rapid construction as each block is said to displace six ordinary brick.



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BOOKS On Concrete

List No. 1—Reinforced Concrete Engineering Design

(Prices quoted are for cash in advance, and include postage)

GENERAL ENGINEERING HANDBOOK. By Charles Edward O'Rourke and 29 associates. Flexible cover; 921 pages, 5 by 8 in., numerous tables, diagrams, and illustrations. Price **$4.00**

This book assembles a great amount of fundamental engineering data in usable form, 31 separate sections dealing with as many specific branches of engineering. Of particular interest to engineers who specialize in the use of concrete as a structural material are sections devoted to "Highways," by Thomas R. Agg; "Reinforced Concrete Structures," and "Stresses in Framed Structures," by Charles Edward O'Rourke; "Engineering Materials," by Herbert H. Scofield; "Foundations," by Roland P. Davis; and "Mechanics," by Alfred P. Poorman.

REINFORCED CONCRETE CONSTRUCTION. By George A. Hool, Professor of Structural Engineering, University of Wisconsin.

Vol. I—Fundamental Principles. Third Edition. 380 pages, 6x9, 139 illustrations, 18 tables, 28 diagrams **$3.50**

Vol. II—Retaining Walls and Buildings. Second Edition. 700 pages, 6x9, illustrated........ **$6.00**

Vol. III—Bridges and Culverts, 688 pages, 6x9, over 600 illustrations, 41 plates........ **$6.00**

CONCRETE ENGINEERS MANUAL. By Samuel Baker and A. DeGroot. Cloth, 401 pages, 5 by 7½ in., numerous drawings, charts and tables. Price **$3.00**

This volume is intended as a textbook for students of concrete engineering, and as a reference book for designers, foremen, inspectors, and others involved in the design of concrete structures and in the making and placing of concrete. The book contains a complete description of the modern methods of proportioning concrete mixtures, mixing and placing concrete and steel, and providing waterproofing. Mathematical tables and the fundamental principles of mathematics and mechanics of materials, as applied to reinforced concrete designs, are included.

Among other subjects treated in individual chapters are form work, foundations, design of retaining walls, and estimating concrete work.

PRINCIPLES OF REINFORCED CONCRETE CONSTRUCTION. By F. E. Turneaure, Dean of the College of Engineering, University of Wisconsin, and E. R. Maurer, Professor of Mechanics, University of Wisconsin. Fourth Edition. Revised and largely rewritten. 461 pages, 6 by 9. Fully illustrated. Cloth Net **$4.00**

A general textbook on design, including material from actual designs relating to experimental results, and the theory of flat slabs.

CONCRETE ENGINEERS' HANDBOOK. By George A. Hool and Nathan C. Johnson, assisted by S. C. Hollister, and with chapters by Harvey Whipple, Adelbert P. Mills, Walter S. Edge, A. G. Hillberg and Leslie H. Allen. 800 pages, 6 x 9. Illus. Flexible binding. Price **$6.00**

A compact reference book, containing tables, formulae and data on plain reinforced concrete, covering the entire field.

HANDBOOK OF REINFORCED CONCRETE BUILDING DESIGN. By A. R. Lord, Consulting Engineer. 261 pages, 5¼ x 7½, 156 tables and diagrams. Flexible leather. Price **$1.00**

A compact yet comprehensive handbook for the designer of reinforced concrete buildings. The author has presented numerous tables and diagrams developed as time savers during his extensive experience in the design and construction of buildings. Use of diagrams is illustrated with solutions of typical design problems.

CONCRETE PLAIN AND REINFORCED. By the late Frederick W. Taylor, Sanford E. Thompson, and Edward Smulski. Vol. I. Theory and design of Concrete and Reinforced Structures. 969 pages, 6 x 9, 311 figures, 42 tables, 25 diagrams. Vol. II. Theory and Design of Continuous Beams, Frames, Building Frames and Arches, 688 pages, 6x9, 224 figures, 5 tables, 31 diagrams. Cloth. Vol. I, **$8.00**; Vol. II, **$7.50**.

For more than twenty years "Concrete, Plain and Reinforced" has been the recognized standard in its field. Volumes I and II are far more complete than the earlier editions that appeared in single volumes.

REINFORCED CONCRETE AND MASONRY STRUCTURES. By Hool and Kinne. 722 pages, 6 x 9, illustrated. Price **$6.00**

The work of 14 specialists. This book offers a practical and detailed discussion of every important element entering into the design and construction of concrete and masonry structures. Particularly noteworthy are the very thorough treatments of Reinforced Concrete Buildings, Concrete Forms, Chimneys and Concrete Detailing.

REINFORCED CONCRETE DESIGN SIMPLIFIED. By James R. Griffith, Professor of Structural Engineering, Oregon State Agricultural College. This is the fourth printing of a series of 38 full-page simplified design charts based on the design regulations approved by the Joint Committee on Concrete and Reinforced Concrete, and by the American Concrete Institute. As a designers' aid these charts are indispensable. Price **$1.00**

ELEMENTARY GUIDE TO REINFORCED CONCRETE. By Albert Lakeman. Seventh edition, revised 1930; 94 pages, 79 illustrations. Price **$1.25**

This book is written for the builder, the student, the foreman, or anyone not having a previous knowledge of the principles of reinforced concrete design. Individual chapters cover loads and reactions, reinforcement, neutral axis, reinforced concrete beams, bending moments, shearing stress, reinforced concrete columns and walls, concrete bases, and concrete foundations.

REINFORCED CONCRETE DESIGNERS HANDBOOK. By Chas. E. Reynolds. Published in 1932; 300 pages, 40 designing tables, 51 illustrations. Price **$5.00**

This book contains complete data for the design of all classes of reinforced concrete structures, written by an engineer who is familiar with the designing practice of the leading British specialists in reinforced concrete.

REINFORCED CONCRETE WATER TOWERS, BUNKERS, SILOS AND GANTRIES. By W. S. Gray. Published in 1933; 256 pages, 170 illustrations, 2 folders. Price **$4.00**

Written by an author with practical experience, this book supplies the designer much needed information on the design of structures of these unusual types. The book includes many labor-saving diagrams. Other subjects include heat transmission through concrete walls and calculation of stresses due to hot liquids. A large part of the book is devoted to construction methods and cost estimating.

REINFORCED CONCRETE RESERVOIRS AND TANKS. By W. S. Gray. Published in 1931; 200 pages, 119 illustrations. Price **$4.00**

This book deals in a thoroughly practical manner with the design and construction of plain and reinforced concrete reservoirs and tanks and other water-containing structures both above and below ground level, and both covered and open types. Joints in floors and walls are given special attention.

SPECIAL COMBINATION OFFER: $1.50 (or $2.00 for Cement Mill Edition) added to the price of any of the above listed books will entitle you to one years subscription to Concrete or extend your present subscription one year from its present expiration date. Foreign and Canadian subscribers please write for details.

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Equipment and Materials

FLURESIT of a new type, a product of the American Fluresit Company, Cincinnati, has recently been tested by the H. C. Nutting Co. of Cincinnati. A report of the tests of concrete cylinders made by the Nutting company is available. The addition of Fluresit to mortar or a lean top finish for cement floors, it is said, increases the strength over 55 per cent.

◆ Industrial Literature ◆

BLAW-KNOX offers a wide selection of truck mixers and agitators, in 1, 1½, 2, 3, 4 or 5 cu. yd. sizes, for ready-mixed concrete plants, material dealers and contractors, all described in a recent folder.

Concrete buckets are illustrated in Bulletin 1424.

Form 1349 illustrates and describes the Blaw-Knox adjustable float bridge for longitudinal floating and joint finishing.

Form 1273 covers the Blaw-Knox lip curb rail equipped with "jiffey clamps."

●

TERRAZZO is a new catalog being distributed by Universal Atlas Cement Co., Chicago, to architects, containing 24 natural color reproductions of fine terrazzo and several actual color photographs of beautiful terrazzo installations especially helpful in visualizing the effects that may be obtained in fine terrazzo floors. In addition this book contains specifications for terrazzo work as adopted by the National Terrazzo and Mosaic Association.

●

OVER the Rough Spots is the title of a 24-page booklet on floors and their care, just published by the Stonhard Company of Philadelphia. It explains how a handy man can repair holes, ruts or breaks in factory and industrial floors or platforms, preserve and harden concrete floors for longer wear, bonding floor and walls, making them acidproof and waterproof, leveling up worn trucking aisles, etc., they say, without chipping or chopping of the old surface.

●

THE Universal Form Clamp Company of Chicago has two pieces of literature for distribution—one illustrating and describing their form clamps, insert-spreader and rod-cutter with form clamps and plain rods; the other, Uni-Forms, with renewable faces for concrete construction.

●

RUBBER Expansion Joint is the title of a 16-page booklet being distributed by the Philip Carey Company, Cincinnati, setting forth the advantages of this product for roads and pavements, bridges, sea-walls, sewage disposal plants, tunnels, buildings and floors.

Among the Manufacturers

CHAIN BELT COMPANY of Milwaukee, Wisconsin, has recently completed the transfer to Milwaukee of all of the manufacturing operations of its wholly owned subsidiary, the Stearns Conveyor Company of Cleveland, Ohio. The last operation to be moved to the Milwaukee plant is the manufacture of the Rex-Stearns Belt Conveyors Idlers.

●

THE Johnson-Marsh Corporation, producer of the Hunt Process and Ritecure methods for curing concrete, has moved its eastern office from Long Island City to 52 Vanderbilt Avenue, New York City.

New literature on these two methods of curing has recently been issued.

●

THE T. L. Smith Company, Milwaukee, recently received an order from the Tennessee Valley Authority for three 3-yard Smith mixers to be used in constructing the new Norris Dam near Knoxville, Tennessee. These mixers are of the same general type as the six 4-yard Smith mixers at Boulder Dam.

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Advertisers' Index

American Steel & Wire Co.	Inside Front Cover
Anchor Division of Consolidated Concrete Machinery Corp.	29
Automatic Sealing Vault Co.	27
Barnsdall Tripoli Co.	32
Besser Manufacturing Co.	29
Books	30
Brookmire, Inc.	28
Calcium Chloride Association	25
Classified Liners	31
Colorcrete Industries	29
Columbia Alkali Corp.	25
Concrete Pipe Machinery Co.	31
Consolidated Concrete Machinery Corp.	29
Conwell, E. I., Co.	31
Dow Chemical Co.	25
Dunn, W. E., Mfg. Co.	29
General Motors Truck Co.	Back Cover
Giant Portland Cement Co.	29
Ideal Division of Consolidated Concrete Machinery Corp.	29
International Cement Corp.	21
Jaeger Machine Co.	28-29
Kaplan, J.	31
Lackey, H. W.	31
Lone Star Cement Co.	21
Malleable Iron Fittings Co.	32
Mepham, Geo. S., & Co.	26
Michigan Alkali Co.	25
Mortorless Tile Machine Co., Inc.	26
Neider, F. A., Co., The	28
Piccadilly Hotel	28
Porter, H. K., Inc.	27
Portland Cement Association	2
Professional Service	31
Servicised Products Corp.	23
Solvay Sales Corp.	25
Universal Division of Consolidated Concrete Machinery Corp.	29
Williams, C. K., Co.	26
Williamsport Wire Rope Co.	Inside Back Cover

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Its pages are devoted to discussions of plant design, management, operation, production efficiency, chemical research and control, quarry operation, progress and news of the industry.

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Concrete

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CONTENTS

The Heat of Hydration of Portland Cement Pastes—By Wm. Lerch and R. H. Bogue 36

Cement Statistics for January 42

Editorial 43

Look to the Highway Market.

The Menace of the Silicosis Racketeer.

Slag Cement.

Cement Plants Start Expansion of Distribution Facilities 44

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INDEX TO ADVERTISEMENTS

Allis-Chalmers Mfg. Co. ....
Cement Process Corp. 33
Engineering & Designing 31
General Motors Truck Co. .... Back Cover
Link-Belt Co. 34

Cement Mill Section of
Concrete

Vol. XLII
No. 4

APRIL
1934

The Heat of Hydration of Portland Cement Pastes

Two Methods of Obtaining Heat of Hydration—Determined for Four Major Compounds of Cement—Computing Total Heat Liberated At Any Age

By WM. LERCH† and R. H. BOGUE‡

Abstract

WHEN water is added to portland cement, heat is liberated, the rate and amount being a function of the composition of the cement. The heats of complete hydration have been determined of the four major compounds of portland cement, $3CaO.SiO_2$, $2CaO.SiO_2$, $3CaO.Al_2O_3$ and $4CaO.Al_2O_3.Fe_2O_3$. By the use of these values, and determinations of the heat of hydration which has occurred at any age, the percentage of the total available heat that has been liberated at that age may be computed. Two methods are described for use in obtaining the heats of hydration; one for ages up to 48 hours and the other for any age of paste greater than 1 day.

I. Introduction

WHEN water is mixed with portland cement, reactions take place as a result of which heat is evolved. Under usual conditions of concrete construction, the heat is dissipated rapidly by radiation and temperature changes within the structure are but slight and probably of little consequence. But in concrete structures of very large mass, the heat is not readily radiated and, especially under hot climatic conditions, the mass of the concrete may attain high temperatures. These temperature rises cause expansion while the cement is hardening, and may result in contractions and cracking when the eventual cooling to the surrounding temperature takes place.

Again, during construction in cold weather, special care must be exercised in the placing of concrete to insure that the grout does not freeze. Since the reactions of hydration evolve heat, they are capable of producing a degree of auto-protection against an outside temperature which might otherwise cause freezing or an inhibition of the hardening process.

For each of the above conditions of construction it is desirable that information be available on the total quantity of heat which may be evolved from the cement and especially on the rate at which this heat is liberated. The present investigation was undertaken to determine the influence of the cement constitution, surface area and temperature on the quantity and rate of heat evolution from cements.

It appears that the processes occurring in portland cement pastes which affect the quantity and rate of heat evolution may be divided into two major classes: the heat liberated (or absorbed) by solution of the anhydrous materials, and the heat liberated (or absorbed) by the precipitation of hydrates from solution. The problem is simplified, however, since, algebraically, the heat of solution of the anhydrous materials, plus the heat of precipitation of the hydrates, is equal to the heat of hydration. The term "hydration" as herein used is the more general expression which includes whatever of hydrolysis may have occurred in any particular case. Furthermore, the precipitation of hydrates cannot lag appreciably behind the solution of anhydrous materials since the compounds involved are but slightly soluble. Hence the net heat evolved at any given age following the set of the paste is due almost entirely to the hydration which has taken place up to the time of test.

The materials selected for study included the major cement compounds[1], tricalcium silicate, beta dicalcium silicate, tricalcium aluminate, and tetracalcium alumino ferrite, a number of laboratory cements prepared from commercial raw materials and burned in an experimental rotary kiln to give clinkers of systematically varying compositions, a number of commercial cements, and several definite particle size fractions obtained from one of the commercial cements.

II. Preparation of the Cement and Cement Compounds

The cement compounds used in this investigation were prepared from chemically pure oxides and burned in an up-draft gas fired kiln in the manner described in a previous report.[2]

The laboratory clinkers* were prepared from commercial raw materials burned in an eight-foot, gas-fired rotary

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‡Research Director, Portland Cement Association Fellowship, Bureau of Standards, Washington, D. C.

Publication approved by the Director of the National Bureau of Standards, U. S. Department of Commerce. Paper No. .... of the Portland Cement Association Fellowship at the Bureau of Standards.

*These clinkers and cements were prepared by W. C. Taylor, of the Portland Cement Association Fellowship staff.

kiln. The temperatures used in making these cements were the minimum temperatures required to obtain complete, or nearly complete, combination as determined by free lime tests.[3] Gypsum was added to the cement clinkers to give 1.8 per cent SO_3 and the cements were ground in a laboratory pebble mill to such fineness that 87.5 ± 0.5 per cent passed the No. 200 sieve.

The commercial clinkers were obtained from the manufacturers. One of these was ground in a laboratory mill to the desired fineness and several particle size fractions separated from the ground clinker by air elutriation. Cements for test purposes were made from the clinker fractions and the clinker as ground by the addition of 2.5 per cent of gypsum. The clinker and gypsum were placed together in a small pebble mill with a very light charge of flint pebbles and the mill rotated for fifteen minutes to accomplish intimate mixing.**

III. Apparatus and Experimental Procedure

Two methods were used to determine the heat of hydration of cement pastes: (1) the heat of hydration was calculated from the differences in the heats of solution, in a suitable solvent, of the hydrated and unhydrated cement pastes and, (2) the heat of hydration was measured directly.

1. *Apparatus and Procedure for Heats of Solution*—The calorimeter used for measuring the heats of solution was designed by R. S. Jessup and P. Rapp in 1925 to measure the heat of hardening of cement pastes and was later modified by W. Lerch and F. C. Hornibrook for heats of solution. The water jacket of the calorimeter, of 2,500 *ml* capacity, was constructed of nickel plated brass. The jacket contained a well 13 *cm* deep and 10 *cm* in diameter to receive the calorimeter vessel and was provided with a cover 2 *cm* thick connected to the jacket in a manner that provided circulation of water from the jacket reservoir through the cover. Circulation of the water was effected by a motor-driven rotary stirrer made of brass. A nicrome wire coil, of 15 ohms resistance, connected through a variable resistance to a 220-volt alternating current line, provided the means of heating the water in the calorimeter jacket.

The calorimeter vessel was a cylindrical brass vessel of 500 *ml* capacity, plated with gold and provided with a bakelite cover 1.5 *cm* thick containing a groove 0.5 *cm* deep fitting snugly over the rim of the vessel. The air space between the calorimeter vessel and its containing well in the water jacket was 1 *cm* in width. The stirring of the liquid in the calorimeter vessel was effected by a motor-driven rotary stirrer. The shaft of the stirrer was so constructed that it made an air-tight joint where it passed through the brass tube in the cover of the calorimeter jacket, eliminating diffusion of air between the calorimeter and its environment.

The calorimeter was operated adiabatically and observations of the temperature differential between the liquid in the calorimeter vessel and the water in the surrounding jacket were made by means of a 5-junction copper-constantan differential thermoelement connected to a Leeds-Northrup galvanometer with scale. The thermoelement junctions were placed in a 0.5 *cm* glass tube, sealed at one end, the tubes then filled with paraffin, one tube immersed in the liquid of the calorimeter vessel and the other tube in the water reservoir of the jacket. When the jacket temperature became too low, as indicated by the reading on the galvanometer scale, heat could be supplied by means of the heating coil in the jacket. If the jacket temperature became too high, cold water could be added to the jacket to bring about the necessary temperature drop.

Temperature measurements of the liquid in the calorimeter vessel were made by the use of a calibrated 5-junction copper-constantan thermoelement junction connected to a galvanometer and a type *K* Leeds and Northrup potentiometer. The thermoelement junctions were placed in glass tubes in the manner previously described, one tube being immersed in the liquid in the calorimeter vessel, the other tube being immersed in an ice bath. It was stimated that the differential temperature readings taken in this manner are correct to 0.005 deg. C. over the range required.

The stirrer, glass tube containers and the heating coil immersed in the liquid in the calorimeter vessel were coated with a cellulose lacquer to protect them from attack by the solution. For the acid solutions used in this investigation, the lacquer provided an excellent protection.

The heat capacity of the calorimeter, with the vessel containing 350 *g* of solution, was determined with electrical energy. The amount of electrical energy input in any given experiment was computed from the time, which was measured with a 0.2 second stop watch, the resistance of the constantan wire heating coil, which was 20.04 ohms, and the current flowing through the heating coil which was determined by measuring the potential drop across a standard one-ohm coil in series with the heating coil.

The heat capacity experiments were carried out in the following manner: The apparatus was assembled, the stirrers set in operation, and the temperature of the calorimeter vessel and the jacket adjusted to the same initial value of 25 ± 0.5 deg. C. After equilibrium was established, observations of the calorimeter temperature were made in a 15-minute "fore" period. In the 15-minute calorimetric "reaction" period, electrical energy was supplied for about 5 minutes, allowing 10 minutes for equilibrium to be established. And, finally, observations of the calorimeter temperature were made in a 15-minute "after" period. The corrected calorimetric temperature rise was taken as equal to the observed rise in temperature of the calorimeter from the beginning to the end of the "reaction" period less the average of the temperature changes which occurred in the "fore" and "after" rating periods.

A similar procedure was followed in the heat of solution experiments, with the electrical energy being replaced by the energy evolved on dissolving the cement in the solution. In the calorimetric "reaction" period, the calibrated thermoelement was removed from position and replaced by a funnel through which the cement, whose temperature was 25.0 ± 0.5 deg. C., was added at a more or less uniform rate for about 5 minutes. Then the funnel, the end of which extended to about 1 *cm* above the surface of the solution, was removed and the thermoelement replaced. In the heat of solution experiments 3 *g* of cement, calculated on the water free basis, were used. The amount of solution was 350 *g* less that amount of water which would be added in the cement.

**Obtained through the courtesy of Raymond Wilson, Conservation Engineer of the Portland Cement Association.

The electrical energy supplied for the determination of the heat capacity was approximately 2,400 cals., which gave a temperature rise of about 7.0 deg. C. The heat of solution obtained from the cements and hydrated materials varied from 1,450 to 2,200 cals. and the temperature rise varied in these experiments from 4.2 to 6.3 deg. C.

A preliminary investigation of the solubility of portland cement and the cement compounds indicated the necessity of using different acid solutions for dissolving these several materials. The solvents selected for the solution of the cement compounds, the cements, and their hydration products were: for tricalcium aluminate, a two-normal nitric acid solution; for tetracalcium alumino ferrite, a two-normal hydrochloric acid solution; and for the calcium silicates and cements, a solution of two-normal nitric and 0.25-normal hydrofluoric acids. With these solvents complete solution was attained in each case.

2. *Apparatus and Procedure for Direct Hydration*—The calorimeter used for measuring the heats of hydration directly was that employed by P. Rapp and C. H. Jumper[4] for measuring the changes in temperature of cement pastes during setting, and adopted by W. Lerch and R. Briant for determining heat of hydration. The procedure in the present experiments was as follows: The cement and water were thoroughly mixed in a small tin can, copper-constantan thermoelements inserted in the paste and the can placed in a double-walled vacuum flask which was tightly stoppered with a cork stopper. The thermoelements were connected to a recording potentiometer which recorded the temperature of the cement paste at 15-minute intervals.

During the experiments described in this report, the apparatus was set up in a constant temperature room at 21 deg. ± 1 deg. C. (70 deg. ± 2 deg. F.), and all materials were brought to room temperature before starting an experiment. The water was placed in the tin can, the cement was then added and thoroughly mixed with the water by a mechanical stirrer. The stirring was continued for one minute to insure complete and homogeneous mixing of the paste. Three thermoelement junctions were inserted and distributed through the mass of the paste in order to obtain a representative average temperature.

From the data obtained in this manner, the heat evolved by the cement from the beginning of the reaction to any given time can be calculated. The total heat evolved at any given time is equal to the heat absorbed by the calorimeter and contents plus the heat lost by radiation to the surroundings. For this calculation, it is necessary to know the heat capacity and the initial and final temperatures of the calorimeter and contents, and the rate of loss of heat by radiation from the calorimeter.

The heat capacity of the calorimeter was taken as equal to that of the inner wall of the vacuum flask (computed from its mass and specific heat) plus the heat capacity of the tin can plus the heat capacity of the cement paste (calculated as 0.2 and 1.0 cal. per degree for the cement[5] and water, respectively). The radiation loss constant was determined for each vacuum flask by observing the rate of cooling of a definite quantity of hot water in the tin can placed in the flask.

In each experiment 200 *g* of cement and 67 *g* of water were used.

For periods of time longer than 48 hours, this method is not practicable because of the small temperature difference which then exists between the calorimeter and its surroundings.

A number of determinations were made with two commercial cements to determine the reproducibility of the results by this method. In 16 experiments (8 each on 2 cements) the average deviations from the mean values were ±3.2 and 3.0 per cent—or ± 1.8 and 2.0 cal. per *g* respectively. The total heats per gram were 57 and 68 calories, 46 and 55 of which were computed from radiation and 11 and 13 from the temperature rise of the calorimeter.

IV. HEAT EVOLVED ON COMPLETE HYDRATION

The ultimate quantity of heat that can be liberated by a cement, in the absence of secondary reactions, is that quantity which is evolved on the complete hydration of the constituent compounds to the equilibrium condition imposed by the conditions of the test. A knowledge of the heats of complete hydration of the cement compounds permits the computation of the percentage of the total available heat that has been evolved at any age of test. Accordingly, the heats of complete hydration of the cement compounds and of a number of clinkers were determined.

In the preparation of the hydrated materials, the respective compounds and cement clinkers were ground to an impalpable powder and water was added in sufficient quantity to produce a paste of approximately normal consistency.[6] The pastes were thoroughly mixed and placed in an Erlenmeyer flask which was then tightly stoppered and sealed with paraffin wax. These pastes were allowed to hydrate at room temperature for about one month. At that time the flasks were broken away from the hardened pastes, the latter were reground and mixed with sufficient additional water to again give a plastic paste. These mixtures were allowed to continue their hydration as before. The hardened pastes were reground twice at subsequent intervals and treated in a similar manner. After this treatment microscopic and x-ray examination of the hydrated compounds failed to reveal the presence of the unhydrated compounds, except in the case of beta dicalcium silicate which still contained a small amount of unhydrated material, estimated to be about 2 or 3 per cent. Re-examinations of the hydrated compounds at later ages have shown no appreciable changes in the heat values obtained as described and reported below.

It should be pointed out that the term "complete hydration" as used in this investigation refers to a limiting condition of hydrolysis and hydration which the cement compounds in mortars and concretes may be expected to approach but never to exceed. It is for this reason that the values were obtained under conditions of water concentration similar to those encountered in mortars and concretes rather than in an excess of water. Hence the values given may not in all cases denote the theoretical equilibrium condition. As an example, it may be mentioned that the composition of the calcium silicate in equilibruim with saturated calcium hydroxide solution was found to be $3CaO.2SiO_2.nH_2O$. But in mortars the hydrolysis has not been found to proceed appreciably beyond the composition $2CaO.SiO_2.nH_2O$. Hence the values given for the "complete hydration" of $3CaO.SiO_2$ and $2CaO.SiO_2$ represent the heats liberated on conversion to $2CaO.SiO_2.nH_2O$

TABLE I. HEAT EVOLVED ON COMPLETE HYDRATION OF CEMENT COMPOUNDS AND PORTLAND CEMENT CLINKERS

	Partial analyses of cement compounds and of cement clinkers						Computed compound composition of cement clinkers						Heat anhydrous materials	Hydrated materials on ignited basis	Heat evolved on complete hydration	Calc. heat of hydration	Difference between experimental and calc. values
	CaO	Al_2O_3	Fe_2O_3	SiO_2	MgO	B_2O_3	C_3S	C_2S	C_3A	C_4AF	MgO	Free CaO	cal/g	cal/g	cal/g	cal/g	per cent
							Pure compounds										
C_3A	62.3	37.9	0.05	0.01					100	----	----	----	733	526	207	----	----
C_4AF	46.3	20.8	33.0	0.03					----	100	----	----	519	419	100	----	----
C_3S	73.8	0.1	0.06	25.8			100		-	--	----	----	632	512	120	-	-
βC_2S	65.1	0.1	0.06	34.4	----	0.4		100	-	--	--	----	563	501	62		--
CaO^7	----	----	----						----	----	----	----	828.9	550.3	278.6	--	----
MgO^8									---	--	----	----	862	659	203		--
							Clinkers, series K-3										
No. 4	63.7	4.0	4.9	23.9	3.1		44	36	2	15	3.1	0	623	526	97	100	+3.1
No. 5	64.7	7.0	2.0	22.1	3.7		46	29	15	6	3.7	0	649	523	126	118	—4.8
No. 15	66.6	7.4	1.7	19.8	4.0	----	62	10	17	5	4.0	1.5	666	521	145	133	—8.3
No. 17	65.4	5.4	5.5	20.0	3.3	----	69	5	5	17	3.3	0	638	519	119	120	+0.8

rather than to the hypothetical equilibruim composition of $3CaO.2SiO_2.nH_2O$.

The results obtained from this phase of the investigation are given in Table I. The data presented in the table include the composition of the materials examined, the heat of solution of the anhydrous materials, the heat of solution of the hydrated materials on the ignited basis, the heat evolved on complete hydration, obtained by the difference between these two and, in the case of the cement clinkers, the calculated heat of hydration computed from the compound composition of each clinker.

It is shown that the heats of complete hydration of the cement compounds, as obtained in this study, are as follows:

Tricalcium aluminate	207 calories per gram
Tetracalcium alumino ferrite	100 calories per gram
Tricalcium silicate	120 calories per gram
Beta dicalcium silicate	62 calories per gram

Four determinations were made on each compound. The probable error of the determination is computed to be ± 3 calories per gram.

The values given for lime [7] (278.6 calories per gram) and magnesia [8] (203 calories per gram) were available in the literature and were not redetermined in this investigation.

The heat of hydration of $3CaO.Al_2O_3$ to $3CaO.Al_2O_3.6H_2O$ has been reported by Thorvaldson [7] as 214.3 calories per gram. Considering the difficulties involved in preparing these compounds in pure form, this value is in good agreement with results obtained in the present investigation.

The values obtained for the complete hydration of the cement clinkers shown in Table I are in fair agreement with the values for complete hydration computed from the compound composition of the clinkers. The values obtained for the heat of solution of the anhydrous and hydrated clinkers are larger than the values which would be obtained from calculations using the heat of solution of the several compounds as given in the table. This is probably due to the use of different solvents in determining the heat of solution of the several cement compounds. However, the heats of hydration of the clinkers when calculated by this method are identical with the calculated values obtained from the heat of hydration factors of the individual compounds. The percentage differences between the experimental and the computed values are shown to range from +3.1 to —8.3, the experimental value being taken as the basis of comparison. It can not be stated at this time if these divergencies are due solely to experimental error or if they involve some inherent characteristics of the cement clinkers whereby the latter differ slightly from the cement compounds when prepared separately. However, these differences are relatively small.

The generally satisfactory agreement between experimental and computed heats of complete hydration leads to the belief that secondary reactions, if they occur on the hydration of clinkers, are relatively insignificant so far as heat transfer is concerned, and that the total heat available on the hydration of a clinker may be computed with a fair degree of precision from the heats of hydration of the constituent compounds.

The only essential difference in composition between a clinker and a cement is the presence of calcium sulfate in the latter. This is usually added to the clinker in the form of gypsum ($CaSO_4.2H_2O$) but, during the grinding process, the gypsum may have been partially or completely dehydrated to plaster ($CaSO_4.\frac{1}{2}H_2O$) or soluble anhydrite ($CaSO_4$) respectively. The calcium sulfate has been found to react with tricalcium aluminate hydrate during set or early hardening to form calcium sulfoaluminate ($3CaO.Al_2O_3.3CaSO_4.31H_2O$). In computing the total heat available from the hydration of a cement it is accordingly necessary to consider the heat involved in the hydration of the plaster or anhydrite and the heat involved in the reaction of the hydrated gypsum with the hydrated tricalcium aluminate to form calcium sulfoaluminate.

For the reactions—

$$CaSO_4.\tfrac{1}{2}H_2O\ (c) + 1\tfrac{1}{2}H_2O\ (l) = CaSO_4.2H_2O\ (c), \text{ and}$$

$$CaSO_4\ (c, \text{soluble anhydrate}) + 2H_2O\ (l) = CaSO_4.2H_2O\ (c)$$

the heats evolved are, respectively, 3.7 and 2.7 kilocalories per mol,[9] or 46 and 34 calories per g SO_3. With the usual percentages of calcium sulfate in cement, this represents a heat value of about 1 cal per g of cement. Inasmuch as the extent of dehydration of the gypsum during grinding is a variable and indeterminate quantity and the heat involved is slight, it appears best to avoid the introduction of a heat factor for the calcium sulfate hydration in the computations of total available heat from cements.

The heat liberated by the reaction—

$$3CaO.Al_2O_3.6H_2O(c) + 3(CaSO_4.2H_2O)(c) + 19H_2O(l) = 3CaO.Al_2O_3.3CaSO_4.31H_2O(c)$$

was computed to be about 149 calories per g of SO_3. This calculation was made from data obtained in the present investigation on the heats of solution of $3CaO.Al_2O_3.6H_2O(c)$ and $3CaO.Al_2O_3.3CaSO_4.31H_2O(c)$ in aqueous HCl and from the data on $CaSO_4.2H_2O(c)$ given in the International Critical Tables. Since the foregoing reaction has been found generally to occur during the setting process or shortly thereafter, and the value is significant, it appears proper to take it into consideration in the computations of total heat available on the complete hydration of cements. This has been done in the computations appearing in Tables II and III referred to later in the paper.

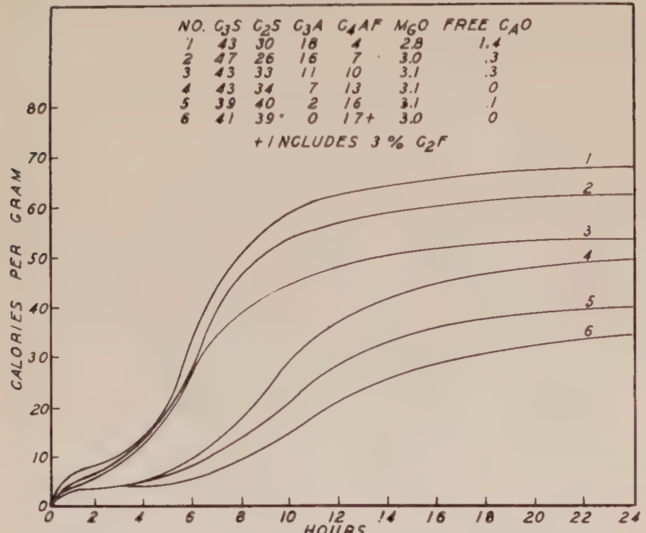


FIG. 1. HEAT EVOLUTION FROM CEMENTS IN WHICH C_3A AND C_4AF ARE THE MAJOR VARIABLES

V. The Rate of Heat Evolution at Early Ages by the Direct Hydration Method

A large number of cements have been examined by the direct hydration method to determine the quantity of heat evolved at ages up to 48 hours. By this method it was possible to calculate the heat evolved at hourly intervals. Some of these results are presented in the accompanying figures which show the values obtained during the first 24 hours.

The materials examined in this part of the investigation included 61 laboratory cements prepared from commercial raw materials to give clinkers of systematically varying composition and ten commercial clinkers. Gypsum was added to give 1.8 per cent SO_3 and the materials ground to such fineness that 87.5 ± 0.5 per cent passed the No. 200 sieve.

In the case of the laboratory cements, the raw materials were proportioned with the intent of varying certain compounds in the clinker and maintaining the other compounds constant. The clinkers were analyzed, including the free lime determination, and the compounds computed. Although the final computations showed that compositions were not precisely as designed, the nature of the effects of composition on rate of heat liberation is clearly indicated.

The results obtained on cements wherein the tricalcium aluminate was decreased by substituting ferric oxide for alumina are shown in Figure 1. These results indicate that each decrease in the tricalcium aluminate content is accompanied by a decrease in the quantity of heat liberated during the first 24 hours. In the figures, abbreviations in the formulas of the compounds have been used as follows:

$C_3S = 3CaO.SiO_2$
$C_2S = 2CaO.SiO_2$
$C_3A = 3CaO.Al_2O_3$
$C_4AF = 4CaO.Al_2O_3.Fe_2O_3$

Figure 2 shows the effect of decreasing the tricalcium silicate and increasing the dicalcium silicate with all other factors substantially constant. These results indicate that each decrease in the tricalcium silicate content is accompanied by a decrease in the quantity of heat liberated during the first 24 hours, with the exception of cement No. 57. This cement contained 2.1 per cent free lime, a compound which hydrates rapidly and liberates a large quantity of heat per unit weight.

The results obtained with cements in which the magnesia content is varied are shown in Figure 3. In these cements the tricalcium aluminate and tetracalcium alumino ferrite were maintained constant and the calcium oxide and silica were adjusted to maintain a substantially constant tricalcium silicate content. Thus, the dicalcium silicate decreased as the magnesia increased. Varying the magnesia content in this manner results in only slight differences in the quantity of heat liberated at 24 hours and the results show no definite trend with relation to the magnesia content.

The heat data from three commercial cements which were ground in a laboratory mill to three degrees of fineness have shown that the rate with which the heat is liberated increases with increased fineness. The data on one of these cements are plotted in Figure 4. The other two cements gave similar results. It is observed that the reaction occurs earlier with the finer cements but that, at 24 hours, the total amount of heat evolved is not greatly different for the different degrees of grinding. At 48 hours the differences became even smaller.

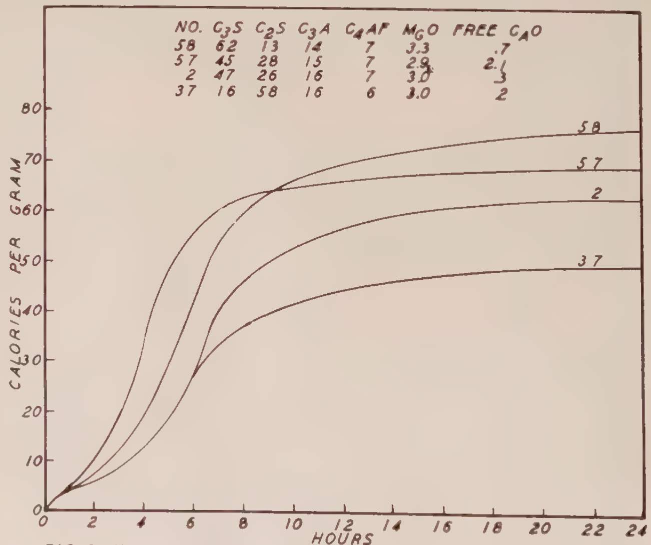
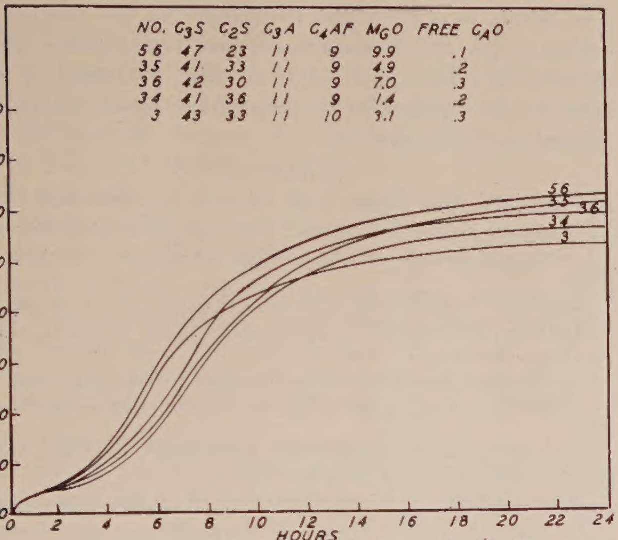


FIG. 2 HEAT EVOLUTION FROM CEMENTS IN WHICH C_3S AND C_2S ARE THE MAJOR VARIABLES

Still other factors which have been found to contribute to the differences in the rate of heat evolution at very early ages are the temperature of the paste during hydration, the water-cement ratio and the quantity of retarder present. The effects of these factors, however, become small after 48 hours.

The curves presented in this report, showing the heat evolved at various time intervals, are of interest in a consideration of the processes occurring during the setting and hardening of the cement. In general, the curves contain four distinct phases. There is an initial rise in the temperature with all compositions, which occurs during the first few minutes. This is followed by a period in which there are only slight thermal changes; the duration of this period varies from a few minutes to several hours, depending on the composition of the cement. In the third phase there is a rapid evolution of heat followed by the fourth phase wherein the thermal changes become relatively slow.



NO.	C_3S	C_2S	C_3A	C_4AF	MgO	FREE CaO
56	47	23	11	9	9.9	.1
35	41	33	11	9	4.9	.2
36	42	30	11	9	7.0	.3
34	41	36	11	9	1.4	.2
3	43	33	11	10	3.1	.3

FIG. 3 HEAT EVOLUTION FROM CEMENTS IN WHICH MgO AND C_2S ARE THE MAJOR VARIABLES

The initial rise appears to be due to the heat of wetting, the mechanical heat of stirring, and probably in part to the heat of solution. This is indicated by the observation that the maximum temperature of this period has been reached in the first few minutes—that is, by the time the first temperature reading is recorded.

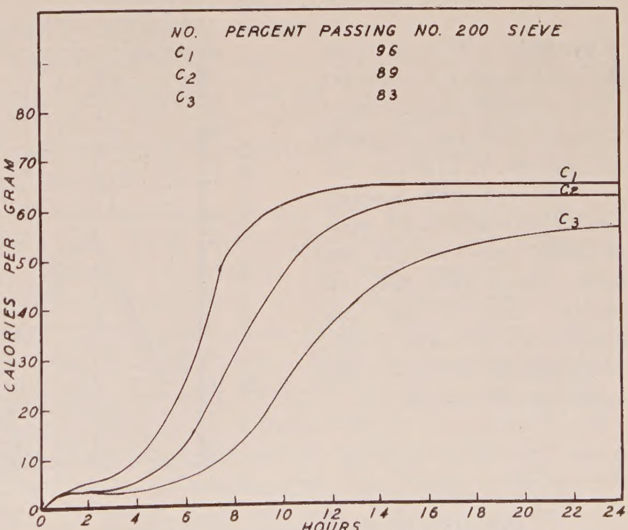
The next period, in which there is a very slow evolution of heat, is a period in which it appears that the water is becoming saturated with the various compounds of the cement. The rate of solution is then dependent on the relative solubility of the various compositions used, on the fineness of the cement, and on the temperature of the paste during this period.

The period of rapid evolution of heat appears to be a period of rapid solution of anhydrous material and precipitation of hydrated material. The algebraic sum of these processes for the compounds of cement is, at this stage, highly exothermic. It has been observed that the beginning of this period of rapid evolution of heat occurs at about the same time period as that at which the initial set takes place.[4] The layer of hydrated crystals and amorphous hydrated material, deposited around the unhydrated portion of the grains, as also the depletion of the solvent, tend to retard the further penetration of water and hydration of the cement. This results in a diminuation in the rate of evolution of heat in the succeeding periods, even though the hydration has not approached completion in that time.

A number of observations support these postulations. A microscopic study of the process of hydration of tricalcium aluminate and tetracalcium alumino ferrite gives evidence of the formation within a few minutes of crystals of a hydrated phase. This would lead to the conclusion that these materials dissolve rapidly, which is in agreement with the nature of the data obtained with those materials. The microscopic examination of hydrating tricalcium silicate indicates that several hours are required for the first crystals of calcium hydroxide to appear and for the first evidence of colloidal hydrate formation. The experiments with beta dicalcium silicate show no evidence of this period of rapid evolution of heat.

Hence, changes in composition of the cement whereby the more soluble compounds are diminished may be expected to prolong the period of quiescence which precedes the rapid rise in temperature. That condition is especially noticeable in the cements in which the tricalcium aluminate is decreased, and is noticeable to a lesser degree in cements in which tricalcium silicate is decreased. Likewise, in accordance with the above theory, acceleration of the reactions by the physical methods of finer grinding of the cements and higher initial temperature is found to advance the period of rapid heat evolution.

All of the heat data obtained on the laboratory cements at 48 hours were subjected to a mathematical analysis by the method of least squares. As a result of this analysis it became apparent that the heat liberated by the hydration of the free CaO could not be observed when the percentage of free CaO present was not greater than about 0.5 per cent. The heat liberated by CaO on complete hydration at 20 deg. C. was found by Thorvaldson, Brown and Peaker[7] to be 278.6 *cals/g*. Thus, the presence of 0.5 per cent free CaO in clinker would, on complete hydration, contribute 1.4 *cals/g* of clinker at 20 deg. C. (68 deg. F.), which is less than the probable error of the method. Also, the magnesia was found to be without appreciable effect at 48 hours and the effect of the dicalcium silicate could not be evaluated because of the very small amount of heat evolved by that compound at early ages.



NO.	PERCENT PASSING NO. 200 SIEVE
C_1	96
C_2	89
C_3	83

FIG. 4. HEAT EVOLUTION FROM A CEMENT GROUND TO DIFFERENT DEGREES OF FINENESS

A solution of the normal equations, in which tricalcium aluminate, tricalcium silicate and tetracalcium alumino ferrite were assumed to be responsible for all of the heat evolved at 48 hours, produced the following values, representing the heats of hydration at 48 hours contributed by each per cent of the above compounds per gram of cement:

Tricalcium aluminate	1.50
Tricalcium silicate	1.00
Tetracalcium alumino ferrite	.40

Inasmuch as cement compositions are often reported only in terms of the oxide compositions, it may sometimes be desirable to interpret the heat data in terms of the oxides. Since the percentages of the compounds present are a linear function of the percentages of the oxides,[10] the desired transformations may readily be made. The results obtained for the contribution of each per cent of the oxides in the cement to the heat evolution at 48 hours of one gram of cement are as follows:

CaO	+ 4.08
SiO_2	— 7.61
Al_2O_3	— 2.75
Fe_2O_3	— 2.76

In applying these data to cements, the percentage of lime must be corrected for the lime present in the retarder as calcium sulfate.

On applying the factors given above for the cement compounds to the computation of the heat evolved at 48 hours from the 61 laboratory cements, the calculated and experimental heats were found to agree within a probable error of ± 3 *cals/g* of cement.

Ten commercial cements of widely varying composition also were examined in a similar manner and equally satisfactory agreement was found between the computed and experimental results.

Since the *rate* of heat evolution, in contradistinction of the *total* heat of hydration, is sensibly affected by many variables, such as surface area, temperature, available water, retarder present, thermal history of the clinker, etc., in addition to the composition, the heat factors given above can be considered as applying only under the specific conditions of manufacture and test imposed upon the cements investigated. The value of the data lies in the definite effects indicated, due to changes in the composition with a given set of conditions, and under these circumstances the effect on the rate of heat evolution at early ages due to changes in the percentage of the compounds present is clearly shown.

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[5] Hartman, Zement, vol. 3, p. 57, 1927; Rock Products, vol. 30, No. 5, p. 74, 1927.

[6] Cf. Standard Specifications for Portland Cement, Am. Soc. Testing Materials. Federal Specifications for Portland Cement, 55-C-191.

[7] Thorvaldson, Brown and Peaker, Jour. Am. Chem. Soc., vol. 51, p. 2678, 1929; vol. 52, p. 80, 910, 1930.

[8] Roth and Chall, Z. Electrochem., vol. 34, p. 185, 1928.

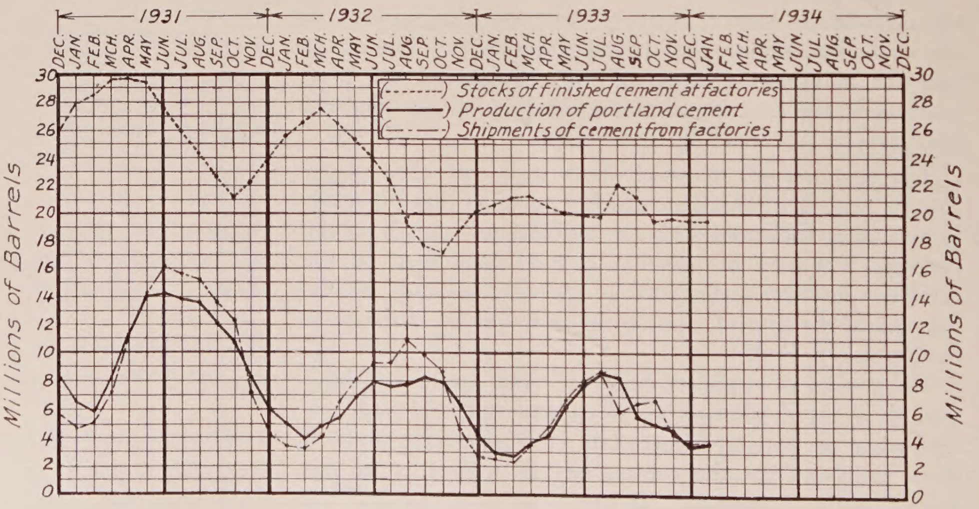
[9] International Critical Tables, vol. V, p. 196.

[10] Dahl, Rock Products, vol. 32, No. 23, p. 28, 1929.

(To be concluded)

Cement Statistics for January

PRODUCTION of portland cement in January, 1934, showed an increase of 27.8 per cent and shipments an increase of 51.0 per cent, as compared with January, 1933. Portland cement stocks at mills were 5.3 per cent lower than a year ago. The factory value of the shipments from the mills in 1933 —64,086,000 bbls.—is estimated as $83,965,000.



Relation of Production to Capacity (Per Cent)

	The Month	Twelve Months
January, 1934	16.6	23.9
January, 1933	12.9	27.6
December, 1933	15.5	23.6
November, 1933	21.2	23.9
October, 1933	22.1	24.5

In this statement of relation of production to capacity the total output of finished cement is compared with the estimated capacity of 163 plants at the close of January, 1934, and of 165 plants at the close of January, 1933.

Production, Shipments and Stocks of Finished Portland Cement (Barrels)

	1933	1934
Production, January	2,958,000	3,779,000
Shipments, January	2,502,000	3,778,000
Stocks at end of month	20,624,000	19,541,000

◆ EDITORIAL ◆

Look to the Highway Market

PERUSAL of the editorial on the front cover of this issue will disclose the fact that the healthiness of the highway market for cement will depend in considerable degree on the federal government during the next twelve months.

For the obvious reason that many states have frittered away their highway funds, diverting these special taxes to general purposes, state highway programs have been crippled to the point where little more than maintenance work can be done with the funds available. This deplorable situation can not be corrected this year, because the legislatures of forty-four states will not be in session until 1935.

The cement industry, therefore, has every legitimate reason for favoring the Cartwright bill calling for appropriation of an additional 400 million dollars to continue the federal highway construction program.

The fate of this bill may be decided within a month. The cement industry should let its voice be heard.

The Menace of the Silicosis Racketeer

UNDER the heading "Menace of Silicosis on Increase," an illustrated article in the October (1933) issue of the Cement Mill Edition of "Concrete" warned the cement industry of the activities of racketeering lawyers and shady doctors in this new field of exploitation.

At the time that article was published these racketeers had confined their attention mainly to the industries that use or produce stone or sand having a high silica content. The prediction was made that in due time they will branch out into other industries.

The recent judgment for $25,000 against the Missouri Portland Cement Company indicates that the warning was timely and the prediction well founded.

Unfortunately for the defendant company in a court action of this character, the sympathy of the jury is easily won by the attorney for the plaintiff. He paints a soul-stirring picture of the ruthless manner in which the unscrupulous corporation has destroyed the health of a poor working man—and unless the company is prepared in advance, he may get away with his melodrama.

In this advance preparation lies the company's best defense. Such precautionary measures should take into account that certain forms of silica dust are actually harmful, and that cement dust, though classified as harmless by all investigators, may induce minor respiratory diseases which can be made to appear far more serious than they are.

Precautionary measures taken at the plant should include the installation of efficient dust-collecting equipment in all departments where dust is generated; periodic medical examination of all men working in dusty locations, and the immediate transfer, to a less dusty department, of any workman who shows any sign of being affected; and the furnishing of respirators for all men working at points where stone dust is generated, especially if the stone has a high content of crystalline silicon dioxide.

Aside from precautionary measures taken at the plant, cement companies should support efforts to include silicosis among the occupational diseases covered by state compensation laws. At present, silicosis is so included in only a few states; but where it is recognized as one of the diseases covered by industrial compensation, little inducement remains to tempt the racketeering lawyer.

Slag Cement

JUDGING from the number of comments and inquiries thus far received as a result of publication of Prof. Budnikoff's article on "Producing Clinkerless Slag Cements," in the March Cement Mill Edition of "Concrete," the American cement industry is interested in this subject.

There is nothing new in this idea of producing a cheaper cement for use in locations where great strength is not required; but much difference of opinion exists with respect to the methods of attaining that end.

Several interesting facts will be found by those who study Prof. Budnikoff's article. For instance, the chemical composition of slags suitable for the manufacture of cement of this type should fall within certain limits—and some of the blast-furnace slags produced in this country meet those requirements.

Another important feature of Prof. Budnikoff's article is seen in his explanation of the chemical reactions that occur during the process of cooling blast-furnace slag. Assuming that the reactions are as he describes them, this explains why dry-granulated slag is regarded as superior to wet-granulated slag for cement manufacturing purposes.

If cements of this and related types are to be produced in large quantity in this country, manufacturers of portland cement who are located near the sources of slag are the logical people to produce them. Under such a situation, fewer attempts would be made to sell the slag cements for purposes for which they are not suitable.

Cement Plants Start Expansion of Distribution Facilities

Santa Cruz and Ash Grove Announce Construction Plans—Many Plants Resume Manufacturing Operations

FROM Portland, Oregon, and from Los Angeles, California, come news reports telling of plans for the expansion of distributing facilities of the Santa Cruz Portland Cement Co.

Two New Distributing Plants for Santa Cruz

At Portland, this company has bought a site for the construction of a storage and distribution plant having a storage capacity of 60,000 bbl. of cement. Construction of the plant is to be started soon. Tentative plans call for the construction of a dock, a warehouse, and from 10 to 12 storage silos. Cement from the company's manufacturing plant will be shipped in by boat and will be unloaded by compressed air through pipe lines connected with the silos. This enables the company to fill orders in bulk or sack and to ship out either by rail, water or truck. The Portland distributing plant will serve the entire northwest.

At Los Angeles harbor the Santa Cruz company has made application for a berth assignment at berth 92, and for a pipe-line easement to private land in the rear of that dock, from which it is inferred that a distributing plant, similar to the one planned for Portland, is contemplated at Los Angeles harbor. Distributing plants of this type are now maintained by this company in San Francisco, Oakland, San Diego, Stockton, and Hawaii.

Ash Grove Expands

The Ash Grove Lime and Portland Cement Co. contemplates considerable new construction at the company's Chanute (Kansas) manufacturing plant. The construction program, in part, includes the erection of five additional storage silos with a total capacity of 100,000 bbl., thereby increasing the plant's storage facilities by 25 per cent.

Plants Resuming Operations

The Osborn (Ohio) plant of the Wabash Portland Cement resumed operations on March 15, at 15 per cent of capacity, adding 30 employes to the former skeletonized force.

At Chattanooga, Tennessee, the Signal Mountain Portland Cement Co. resumed operations on February 27, giving re-employment to 120 men, after a shut-down of six months.

The Duluth plant of Universal Atlas resumed operations on March 1, on a one-third capacity schedule, after having been practically shut down since September 1. Re-employment was given to 150 men.

Another Tennessee plant recently reopened is the Penn-Dixie plant at Richard City, while at Manitowoc, Wisconsin, the Medusa plant has resumed operations after having been closed since September.

The Lehigh plant at Oglesby, Illinois, has reopened, re-employing 250 men, this plant having been shut down since last September.

La Salle, Illinois, reports the reopening of the Alpha plant, near that city, with the re-employment of 200 men.

Other recent reopenings of cement manufacturing plants, as well as increases in rate of production, include the Fredonia (Kans.) plant of the Consolidated Cement Corp., which resumed operations with a full crew of 100 men; the Petoskey Portland Cement Co. plant at Petoskey (Mich.), scheduled to reopen on April 2; the Universal Atlas plant at Hannibal (Mo.), which increased the rate of production to 50 per cent of capacity; the Federal Portland Cement Co. plant near Buffalo, scheduled to employ 50 additional men on April 1; and two plants of the Superior Portland Cement Co., the one at Concrete (Wash.), re-employing 150 men after a long shut-down, and the Seattle plant, which resumed operations at 50 per cent of capacity after having been closed since last July.

Portland Cement Association Regional Promotion Meeting

ENTHUSIASM and confidence — but not over-confidence—prevailed at the regional meeting of the Portland Cement Association at the Palmer House, Chicago, on March 16—one of a series of meetings in principal cities of the United States and Canada. The tough job ahead of the industry was not underestimated, but the progress that has been made and the well organized fight that is being carried on assured the audience that none of the major factors in concrete prosperity are being overlooked.

The morning session was under the chairmanship of T. L. Hughes, assistant western sales manager, Lehigh Portland Cement Company. B. F. Affleck, president, Universal Atlas Cement Company, presided at the luncheon; and the afternoon session was piloted by A. M. Fellows, sales manager, Alpha Portland Cement Company.

Lectures, demonstrations, lantern slides, and pep talks all contributed their share of valuable and timely information.

Cement Advance Expected

It is reported in cement trade circles that an increase in the price of cement is looked for at an early date due to mounting demand from the building trade and construction projects.

American Chemical Society Meets

The semi-annual meeting of the American Chemical Society was held at St. Petersburg, Florida, March 26 to 30, inclusive. A report on this meeting will appear in the May issue.